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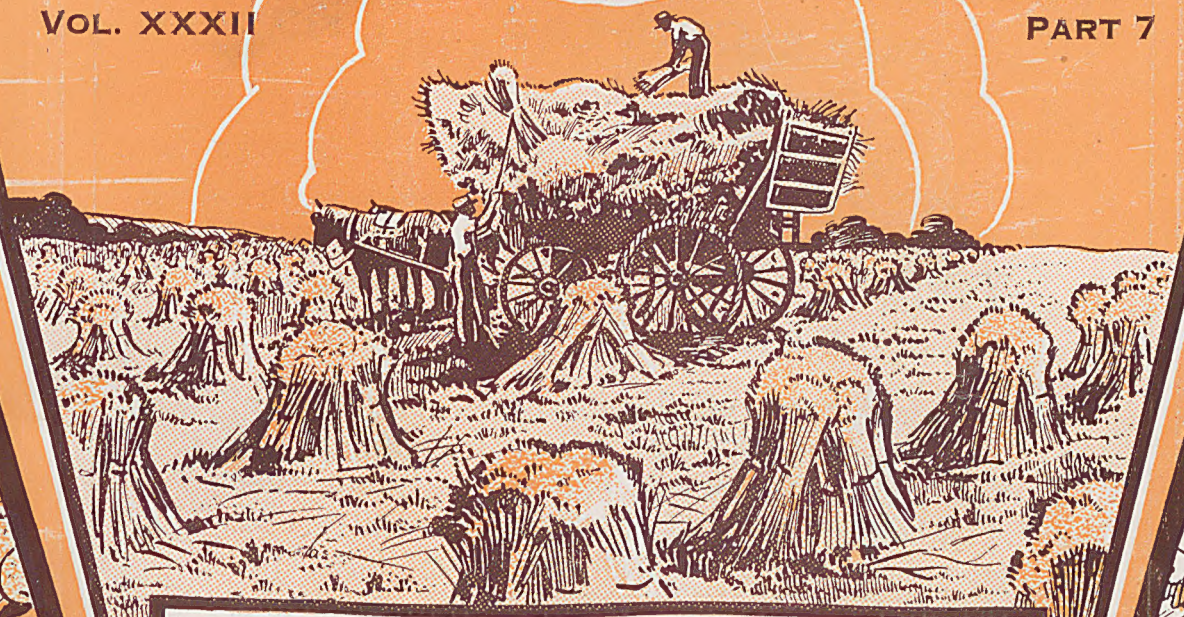

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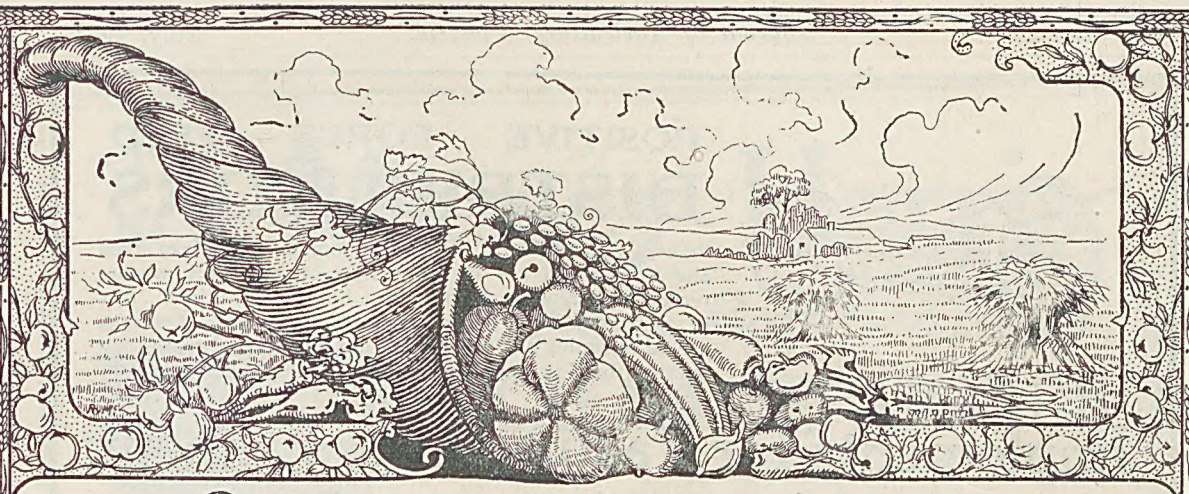

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Issued under the direction of the Hon. J. Allan, M.L.A., Minister of Agriculture.

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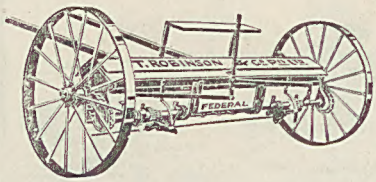

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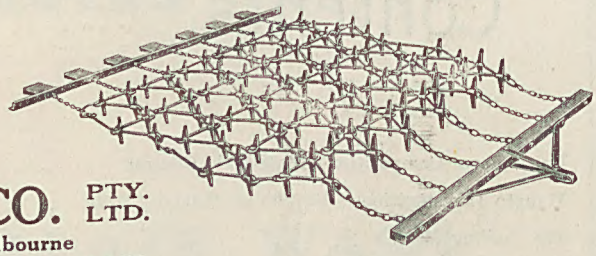

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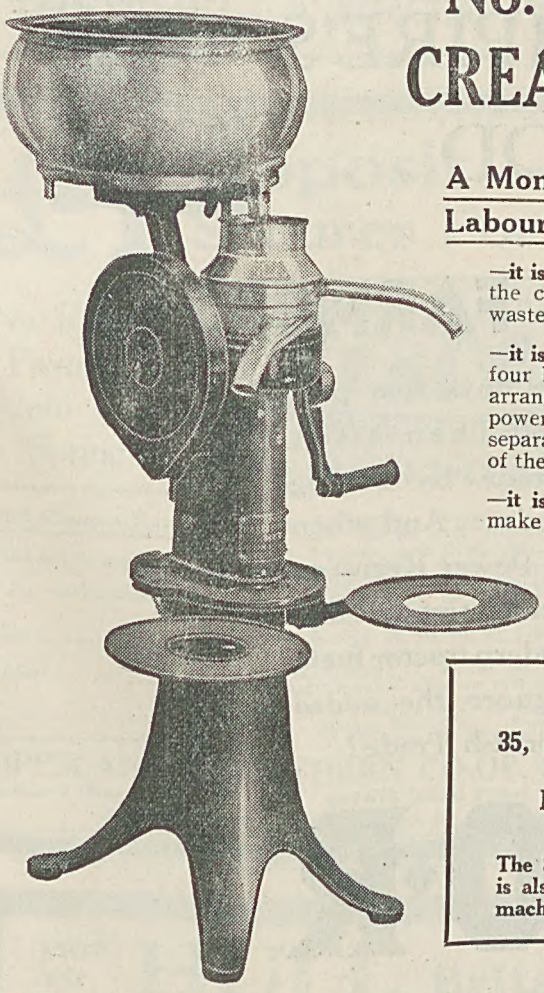

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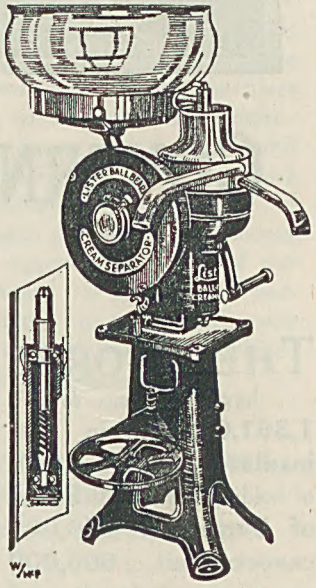

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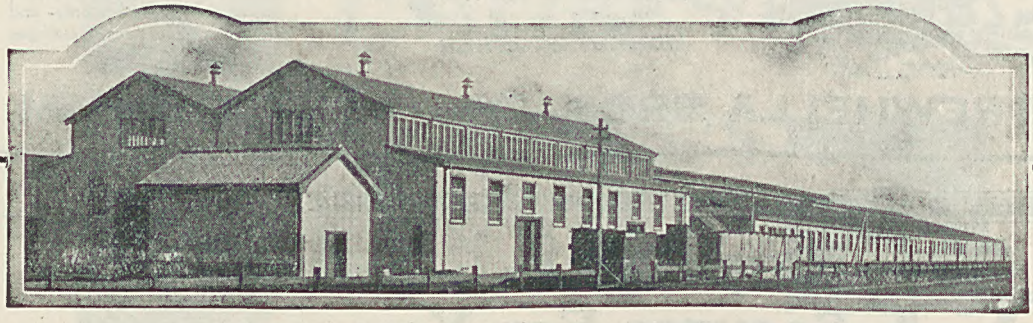

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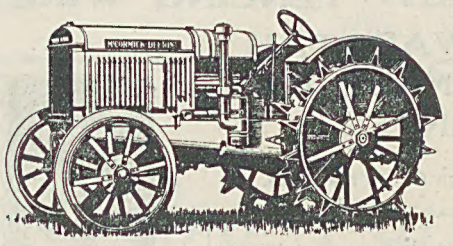

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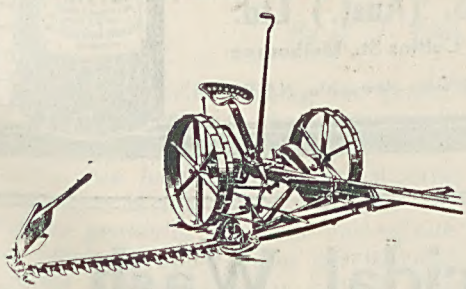

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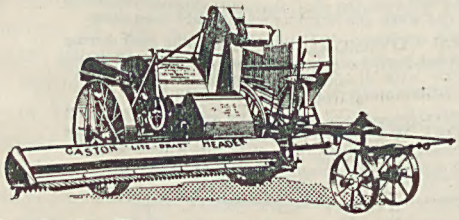

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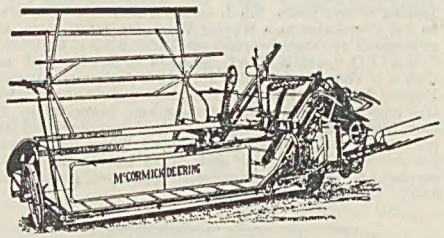

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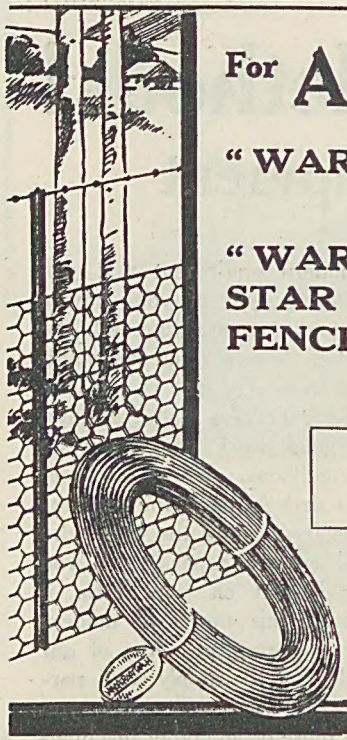

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APPLES AND PEARS : Use 4 gallons of **"VALLO" OVICIDAL WASH** to make 100 gallons of Spray. Spraying may be carried out with entire safety up to the end of August, but is not recommended for use at any later period.

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The Journal of the DEPARTMENT of AGRICULTURE of VICTORIA

Dairy Farm Competition

State Wide Contest

By W. J. Yuill, Senior Dairy Supervisor

WITH low prices ruling for practically all products of the farm, and the suggestion frequently made that overproduction can be met only by restriction of production, it is not to be wondered at that the farmer generally has little enthusiasm for greater efficiency and further development.

In these circumstances, it is both pleasing and surprising to report that only four less entries were received for the Victorian United Cow Test Association's State-wide Dairy Farm Competition than was the case in 1931, when conditions were much brighter.

The members of this organization have been the leaders of the movement for higher farm efficiency in dairying areas, and the educational value of the work has been spread by means of the many field days held on the leading farms entered for the competition.

The all-round quality of the farms competing may be gauged from this report, which shows that no less than twenty-two entries scored over 700 of the possible 970 points.

The competition has been divided into seven main sections and twenty subdivisions, in order that full comparisons may be made of each phase of the dairy farm activity, for the desire of the Victorian United Cow Test Association Council has been to make it in every sense a "Dairy Farm Competition." Prizes have been awarded for several of the sections; therefore a competitor on whose farm there is some excellent feature may receive a prize, although he may not secure a very high position in the aggregate figures of his zone.

A striking illustration of this was shown in the winning zone, where Mr. W. J. Reid and Mr. Geo. Wickham were awarded the Royal Agricultural Society's certificate for first and second farm respectively in the aggregate scores for general superiority, yet neither was successful in winning a section prize.

The Scope of the Competition.

For the purposes of the Victorian United Cow Test Association, the State has been divided into ten zones, and the zones were mapped out as far as possible into areas of uniform physical conditions and interests. In each of these defined areas, a competition is carried on at the same time, and also an interzone competition for the honour of holding the "C.F.C." champion shield, which was donated by the Commonwealth Fertilizers and Chemicals Company. First place in the interzone competition is awarded to the district where the four leading farms are awarded the highest number of aggregate points.

This zone carries the honour of "champion zone" for the year, and the owners of the winning four farms receive a small silver-mounted blackwood miniature of the "C.F.C." shield as a lasting memento of the occasion.

In 1929, the "C.F.C." shield was won by No. 2, a North-Eastern zone, with No. 9, a South Gippsland zone, close up. In the following year, zone 9 led all the others, but lost the shield to zone 6 in the following year. This zone succeeded again in the 1933-4 competition.

The success of zone 6, during the past two years, has been due mainly to the fine showing of the members of the Winchelsea Association. On each occasion three or four leading farms were entered from that district.

Mr. A. Crosthwaite's home "The Hermitage," Gundowring, in the Kiewa Valley. This home has a beautiful garden and is surrounded by lawns.

In the competition under revision, however, this zone is being hard pressed for the honour by zone 1, which lies in the north-eastern area above Wodonga.

The competing farms of No. 1 and 2 zones are to be found mainly along the valleys of north-eastern Victoria, while most of those of numbers 3 and 4 are in the area served by the Goulburn Valley irrigation scheme.

The farms in zones 5 and 6 are mostly in the Western District; those in zones 7 and 8 lie along the main railway line in Eastern and Central Gippsland respectively. Zone 9 lies in close to the South Gippsland line east of Leongatha, and the entrants from zone 10 are located chiefly in the South Gippsland hill country.

The Awards.

In addition to the interzone competition for the "C.F.C." shield and miniatures, there are twenty certificates and forty prizes, i.e., two certificates and four prizes to each of the ten zones.

The Royal Agricultural Society has awarded a first and second certificate to the winner and runner-up in each zone, while the Commonwealth Fertilizer Company has donated ½ ton of superphosphate for the winning farms in sections "B" and "F" of each zone.

D. and W. Chandler Limited provided a prize in each zone for the section "C," which deals with dairy sanitation, the prize being an order for two guineas on any of their stores.

Further prizes of £2 2s. in cash were given for each zone, by the proprietors of the *Live Stock Bulletin.*

The efforts of the council to set up a system which provided opportunity to show approval of some worthy feature of a competing farm would appear to be fully justified, for no less than 31 of the entrants participated in the prizes.

This feature should induce all entrants to remain competitors, even though they may not be in the "top flight," and to try to strengthen any weaknesses as opportunity occurs, hoping some day to reach first place in their zone, possibly with the champion farm of the State.

The Basis of the Competition.

When designing the competition, the framers desired to get away from the age-old system of comparing farms on their "per acre" or "per cow" returns.

It was considered unsound to compare the returns of acres, which may vary greatly, as was the case in this competition, where as high as £50, and as low as £7, ruled in acre values.

Sometimes small herds are found to have very high overhead costs, quite apart from the special conditions and cost for concentrates.

Within the limits of the competition, it was observed that a cow was being maintained on as low as £40, and as high as £180, in actual farm cost. Because of so much variation, it

was deemed necessary, if a rational dairy farm competition was to be introduced, to find a new basis of comparison.

ZONE 1.

Competitor.	Association.	Points.
Thomas Cardwell, senr. ..	Eskdale ..	733·95
A. E. Barton	Kiewa Valley ..	725·2
R. Cardwell	Eskdale ..	720·58
A. Crosthwaite ..	Kiewa Valley ..	711·94
A. D. Ford	Kiewa Valley ..	689·67
H. Lord	Eskdale ..	683·45
J. W. Crosthwaite ..	Kiewa Valley ..	570·74

ZONE 2.

Competitor.	Association.	Points.
F. J. Docking	Alexandra ..	724·20
H. W. Lester	Swanpool ..	698·07
Dobson and Andrews ..	Alexandra ..	693·7
C. Parker	Seymour ..	679·32
M. McLeish	Alexandra ..	656·73
A. G. Evans	Swanpool ..	653·92
J. H. Walter	Alexandra ..	604·58

Therefore it was decided that the value of each competing farm should be arrived at by the judge, the owner of the farm, and a local land valuer—the nominee of the Association of which the competitor is a member. Of course, this body assesses the value of the dairying area only of each farm. In many instances, sheep may be depastured on some light land; or tobacco, beans, maize, potatoes, or onions are grown on selected portions. These parts, and their returns, are not taken into consideration.

"Dairying area" stock are at times agisted elsewhere, and sometimes, as in the case of sheep on irrigation farms, agistment takes place on the "dairying area." These charges are debited or credited to the "dairying area" account by the judges as they arise.

Concentrates, hay, fertilizers, lime, and irrigation charges are called major costs, while dairy returns plus pigs, calves sold off the bucket, and poultry are termed major returns. When these are considered, a figure called the "net return" is found and used in a section dealing with farm returns.

It was considered necessary to allow agistment for the team, the herd sire, and the young stock being reared for herd replacement. A scale of charges was worked out for this purpose as £5 for a draught horse, or a bull, when maintained the whole year on the farm.

In section "G," which deals with farm returns, one point is allowed for each £1 net returns; thus if the net return is £15 per £100 of farm value, the score would be 15 points. Twenty-eight entrants exceeded 20 points; the lowest score was 9 points, and the highest score 56 points. Both Messrs. Batten and Sons, of Panmure, and Mr. W. J. Reid, of Winchelsea, scored high in this section. In each case, good farm management has resulted in low overhead cost per cow, and high carrying capacity and high "nominal" butter-fat per £100 of farm value.

A feature appreciated in this competition is the development of the carrying capacity of the farm. This is usually effected by developing better pastures, the growing of supplementary crops, the use of ensilage and legumes, or by a rational combination of some or all methods.

Nine of the competing farms carried a cow for every £100 or more of farm value; with 36 of the farms, the amount was between £70 and £100; in two cases it was as low as £40, and the highest was £180.

If interest be stated at 5 per cent., it is shown that maintenance or feed cost may be as low as £2, or as high as £9 a year. Where concentrates and agistments were necessary,

Fine stand of lucerne on a Goulburn Valley farm.

this cost was greatly increased. On one farm the figure was as high as £12 per cow, but the milk returns were more than £27 per head, 60 cows returning £1,631.

In sub-section 9, which deals with production, points were awarded for returns per £100 of capital represented in the "dairying area." As there is always a great variation in the composition of the herds, it is first necessary to concede to all junior cows up to four years adequate age allowances; the figure found is termed "nominal butter-fat."

A farm fully stocked with high-producing cows must score higher than one where the cows are few, and the records high; indeed, a well-stocked farm of fair producers will generally score higher than the latter type of farm.

A score of 1 point for each 10 lb. of nominal butter-fat is then allowed, therefore the award to the farm with 450 lb. of nominal butter-fat will be 45 points.

In this section, nine farms scored over 500 lb.; the lowest 180 lb., equal to 50 and 18 points respectively.

Another method used in the competition for allotting points for good farm management, as expressed by the carrying capacity of the farm, is shown in sub-section 16. Under this, 20 points are awarded when there is a mature cow for each £100 of "farm value."

One point more is allotted if an average of one mature cow is carried for each £90 of farm value, and where a cow represents £110 of farm value, there is a corresponding loss of a point.

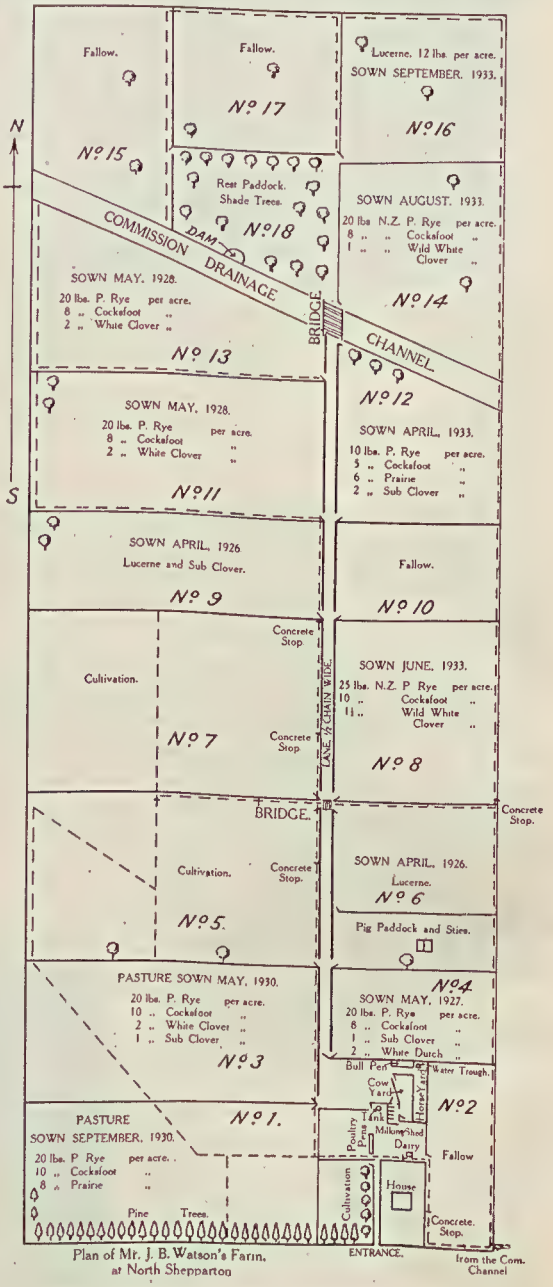
Farm No. 1 carries a cow to £100 of farm value, and scores 20 points.
Farm No. 2 carries a cow to £40 of farm value, and scores 26 points.
Farm No. 3 carries a cow to £180 of farm value, and scores 12 points.

Apart from the sections referred to, the competition has followed well defined ideas of comparison.

The Competition Results.

The judging was carried out by the Senior Dairy Supervisors of the Department of Agriculture. In section "B," which deals with the lay-out of the farm, the geographical difficulties of the locality were taken into consideration. What has been accomplished by Mr. J. B. Watson on his home area at North Shepparton, which is almost flat, could not be attempted by Mr. Wickham at Winchelsea, or Mr. Haywood at Casterton. Each has done well under his particular conditions. A glance at the plan of Mr. Watson's farm will reveal the advantages of the lay-out.

The sheds, yards, gateways, paddock control, water system, shade, &c., are all strong features. There are 17 definite pasture and



Plan of Mr. J. B. Watson's farm at North Shepparton.

cultivation paddocks. The "cow, the sow, and the hen" are fully exploited on this farm. The pigs leave their enclosure only to go to market. The poultry have scratching pens and an exercise run at the rear on good pasture. All the buildings are controlled by a water system from a tank, which is filled by a pump driven by the engine used for all farm purposes. Every paddock abuts on a central lane. No more than one gate need be open at any time, for the lane runs into a rest paddock, in which there is permanent water and shade. The bull pen also has a shelter shed and a ball-tap water-trough. This trough also serves the horse paddock.

Zone 3.

Competitor.	Association.	Points.
J. B. Watson	North Shepparton	730·8
J. W. Reid	North Murchison	723·5
G. Duck	Tongala ..	711
G. Billingham	North Shepparton	680·3
N. H. Moller	Tongala ..	678

Zone 4.

Competitor.	Association.	Points.
J. R. Flegg	Kerang ..	740
J. D. Pierce	Rochester ..	724
M. D. Aitken	Rochester ..	716
Holloway and Butler ..	Swan Hill ..	705
Firth Bros.	Rochester ..	695
Trevan and Thornely ..	Kerang ..	674
A. J. Beale	Murrabit ..	634
J. T. Williams ..	Kerang ..	588

In the sub-section, "Lay-out of Farm, &c.," shelter and shade trees are taken into account. In the 1933-34 competition, four competitors secured full points, and no fewer than 35 were allotted 90 points in all.

Water System.

Twenty-one of the competing farms scored 19 out of a possible 20 points. This statement is in itself sufficient to indicate the high standard of this arm of the farm service. A great variety of systems is called into service, the windmill being quite common, while the engine and pump, hydraulic ram, gravitation systems from hillside, springs, dams, channels, rivers, and creeks are all used according to locality and opportunity.

At Casterton, in south-western Victoria, Mr. H. Haywood has shown what can be achieved by resource and initiative. This farm was originally a section of a wheat-growing area, and had no surface water catchment. To-day, of its 27 paddocks, 26 have permanent water. The supply is mainly through ball-tap fed troughs.

Red Clover on the farm of Mr. W. Hannam of Dean's Marsh. (His herd of 60 averaged 304 lb. butter-fat during last season).

A 12-ft. bank placed across the intersection of two watercourses impounds a considerable body of water, and from here it is pumped by the mill to a 3,000-gallon tank at the house. From this tank, water is reticulated to the house, garden, sheds, dairy buildings, pig-sties, feeding-houses, and a system of water-troughs.

Only recently, Mr. Haywood realized for the first time that inexhaustible supplies of water underground, or in a dam, cannot be controlled if there be insufficient wind to drive the mill. As a last resource, he can, however, open the gates of his 1½-acre water reserve.

Book-keeping and Farm Accounts.

When the competition was inaugurated, the common system met with had the virtue of simplicity—it consisted merely of cheque-butt and bank pass-book. A great improvement on this crude method was shown by 23 of the competitors, who were awarded 18 or more of a possible 20 points. Messrs. J. W. Reid, of Murchison, Batten and Sons, R. T. Mitchell, G. Middleton, F. Johnson, W. Horner, and H. Wettenhall all scored full points.

Home and Surroundings.

It is said that any kind of a house may be a real home, and that a mansion may lack the home atmosphere. Not more than 20 points are given for the home, gardens, and environment. After all, it is a "Dairy Farm Competition." A snug little home with many of the amenities of modern life, which go to make the home bright and a cheery place for the housewife to carry out her necessary duties, need have no pretensions to being a mansion. These features are appreciated by the judges. That 35 of the homes were able to score 18 of the possible points indicates the high standard to be met with in many country homes, and a real pride of ownership.

The maximum points were gained by fifteen competitors. Messrs. T. Cardwell, A. Crosthwaite, H. Lord, C. Parker, and R. Tuff, of the north-eastern zones; Horne, Taylor, Wilsher, and Johnson, of the south-western zones; Sillers, Best, Sennie, Share, and Pearson, of the Gippsland zones, all received high commendation in the judge's reports.

Wanted, a Tree Sense.

In the section for farm lay-out, &c., there was originally a sub-section for "shade and shelter." This feature is now considered when points are allotted for the lay-out of the farm. With the probable exception of the central-western area of Victoria, where the pioneers and their successors have shown a wonderfully developed tree sense, there is a woeful need of more wind-breaks and shade and shelter trees.

Zone 5.

Competitor.	Association.	Points.
H. M. Haywood ..	Casterton ..	773·9
H. J. Batten and Sons ..	Warrnambool ..	761
R. B. Tuff	The Sisters ..	661·8
R. T. Mitchell	Coleraine ..	603·7

One sometimes sees a nice avenue leading to the homestead of a tree-lover. Ornamental trees and shrubs are common enough, and usually lend an attractive appearance to the home setting, but frequently no trees have been planted for the comfort of the stock.

On Mr. Geo. Duck's farm at Tongala, this aspect has been well studied, for a fine lot of trees has been left in every paddock, and his grade Friesian herd makes full use of them during hot days.

Mr. Haywood's farm at Casterton has approximately a mile of plantations. From the older sections, fence posts and firewood are now being used.

Country folk, when visiting the cities, are struck with the lawns, gardens, &c., and wish it were possible to have similar conditions at their homes. Often the "will to do" is the main essential needed. While it is fully recognized that a farm home is a busy one, much is possible at a low initial cost, if the aesthetic sense is present. This is amply illustrated by the fine progress made on so many farms, particularly those of the younger men.

Entrance to the home of Mr. J. B. Watson, North Shepparton. (Trees planted in 1929).

Sanitation and Dairy Hygiene.

It has been thought necessary to consider the dairy buildings in two sections. The first deals with the work up to the time the milk leaves the sheds. The judge considers separately the approaches to the yards and sheds, the gateways, drainage, water-heating apparatus, milking machines, milking methods,

the separator and dairy utensils; then the the cooling system and the dairy for the storage of milk or cream.

Considerable improvement has been shown in this section. The dairy buildings of the farms of zone No. 1 were of a very high standard, and were set in good surroundings. Concrete was used extensively in the dairies, bail yards, shed floors, and drains.

Messrs. A. E. Barton, H. Haywood, D. Horne, G. Wilsher, W. J. Reid, J. B. Sillers, and H. B. Guest, all scored the possible 50 points in the first section, while Mr. F. J. Docking, J. W. Reid (North Murchison), H. Haywood, Geo. Wickham, D. Horne,G. Wilsher, J. B. Sillers, and H. J Rix had dairy conditions for which the judges awarded full points.

No less than 30 competitors scored 45 points or better, in the first section, while 22 scored 23 or more points for their dairy and milk control work. This section has shown considerable improvement. The farms in zone No. 1 are mainly equipped with steam boilers for their dairy work.

In zone 2, Mr. Docking's entry was very favorably commented upon by the judge.

Mr. J. W. Reid and J. B. Watson, of zone 3, have water laid on throughout their dairy buildings; the former has 14 taps at suitable points. Each uses steam or boiling water extensively.

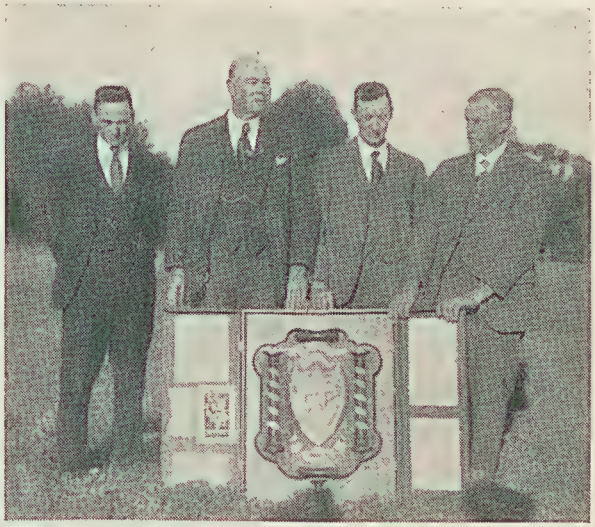
Mr. Flegg, of zone 4, again occupies a high position in this section, and wins the Chandler prize with a score of 69 out of the possible 75 points.

Mr. Haywood's well-known farm secured the similar prize in zone 5 with a maximum score.

In zone 6, Mr. D. Horne and G. Wilsher also scored the full points in their section.

Zone 6.

Competitor.	Association.	Points.
W. J. Reid	Winchelsea ..	763·5
G. H. Wickham ..	Winchelsea ..	743·5
W. H. L. Hannam ..	Winchelsea ..	713·5
D. Horne	Camperdown ..	711·9
N. S. Terrier	Winchelsea ..	682·9
J. C. Taylor	Winchelsea ..	622·5
H. Parish	Winchelsea ..	615·7
G. Wilsher	Winchelsea ..	583·7
W. H. Fleay	Winchelsea ..	579·5
W. G. Farquharson ..	Winchelsea ..	561
G. Middleton	Nalangil ..	544·9
F. E. Johnson ..	Winchelsea ..	544·5



The four leading farmers in the winning zone, No. 6. From left to right.—Messrs. Reid, Horne, Hannam and Wickham.

At a field day held at Mr. Horne's farm recently, the visitors were greatly impressed with this phase of his farm, especially the long trough to hold the machine pipes that are dismantled after every milking, also the steamer and apparatus for thoroughly steaming and cleansing the dairy utensils.

Mr. R. Rautman, of Maffra, secured the highest points in zone 7 for sanitation. Mr. Best and Mr. Sillers, of zone 8, were likewise each allotted the full 75 points. Mr. J. Pearson, in zone 9, and Mr. Wettenhall, in zone 10, were winners of the Chandler prize for their respective zones.

Breeding and Production.

With the exception of two, all the herd sires used were registered as pure-bred. Some of the pure-bred bulls failed to bring about any increase in butter-fat production. A striking case is that of a successful unregistered bull seen on the farm of Mr. F. E. Johnson. The progeny of this sire showed an increase in production of 25 per cent. over that of their mothers.

If a bull is a good specimen of his breed, he may score up to 50 points. Only six bulls received this score, although 40 others were allotted points varying from 45 to 49. Some particularly fine animals were inspected.

In sub-section 10, age allowances are added to all junior cows, and their average production then compared with that of the mature

cows. Any increase is then expressed in percentages, and 1 point is awarded for each 1 per cent. increase shown. This explains why the yields of Mr. Thos. Caldwell's junior cows are shown to be 13.56 per cent. higher than those of the older cows.

Sub-section 11 deals with the number of young stock being reared on the farm. With one exception, all the competitors were found to be rearing heifers for herd replacement. The total of yearlings and two-year olds should be about half that of the number in the milking herd. This section is intended to encourage the practice of selecting and developing the best young stock on the farm; it also offsets any advantage gained by a farm, whereon the whole of the feeding material is utilized for the milking herd.

Sixteen farms were carrying juniors equal in number to that of the dairy cows in the herd.

In sub-section 12 the judge awards up to 30 points for the quality and condition of the herd, the sire, and the young stock.

Some remarkably fine herds were seen. Messrs. Duck, Batten and Sons, Sillers, and Rix were all awarded the maximum points in this section.

Twenty-four others scored 27 or more of the 30 possible points, a splendid indication of the high quality of the competing herds inspected.

It is considered good farm practice to control the herd sire rather than to allow him to run loose—a very common condition on many farms. Where the bull is isolated and under control in a pen or paddock, with shade and shelter, permanent water and feeding arrangements, and a service pen, the judge would award as high as 10 points.

.. The proprietors of the *Live Stock Bulletin* donated a cash prize of £2 2s. for each zone in section "D" which includes the sub-sections 7 to 13. The winners were Messrs. T. Cardwell, C. Parker, N. H Moller, J. R. Flegg, H Haywood, W. H. L. Hannam, R. Rautman, L. Senini, J. Pearson, and H. A. Wettenhall.

Zone 7.

Competitor.	Association.	Points.
R. Rautman	Maffra ..	696
W. F. Treasure ..	Sale	687
G. Johnson	Maffra ..	666
G. E. Currie	Sale	662
P. H. Pedersen ..	Sale	655
W. R. Horner	Sale	638

Zone 8.

Competitor.	Association.	Points.
B. E. Olsen	Narracan Shire ..	727
J. B. Sillars	Narracan Shire ..	720
H. J. Rix	Pakenham ..	692
L. Senini	Narracan Shire ..	667
H. G. Best	Narracan Shire ..	518

Utilization of Skim Milk and Whey.

Some farmers supply milk to the metropolitan areas or to cheese factories; others supply cream to butter factories.

No pigs were kept on nine of the competing farms, and there was no poultry on five farms. On the other hand the quality and quantity of the pig and poultry section has shown a steady improvement since the inauguration of the competition.

The Large White cross pig and the Black Orpington fowls are largely favoured on the majority of competing farms. Mr. M. D. Aitken, of Ballendalla, and Mr. J. B. Watson, of North Shepparton, pin their faith to White Leghorns, which they keep in large

Cutting oats on Mr. J. B. Watson's farm, Shepparton North.

Mr. A. E. Barton's cow-shed and yards. Note the method of removing yard and shed cleanings—two petrol drums on a sledge.

numbers. Mr. Sillers was the only competitor to score the full 50 points in the pig section. Messrs. Watson, Aitken, Horne, Terrier, Share, and Wettenhall all scored 20 points for the quality of their poultry and the conditions under which they were kept.

Pasture and Fodder Crops.

Twenty-nine competitors were considered to have sufficient fodder reserves, and received the maximum points. The class of fodder conservation varied greatly with the zones. In the irrigation areas, lucerne hay is still the prime favorite; red clover, oats, and pasture are largely used, both as hay and ensilage, while sorghum and maize are grown in other areas.

Zone 9.

Competitor.	Association.	Points.
J. Pearson	Dumbalk ..	744·5
J. G. Howell	Leongatha ..	692·5

Zone 10.

Competitor.	Association.	Points.
J. Share	Korumburra ..	718
D. McRae	Wonthaggi ..	694·5
H. A. Wettenhall ..	Korumburra ..	683·5

The pastures still may be much improved. Forty entrants scored 90 or more points out of the possible 100. Mr. Geo. Duck, of Tongala, again scored very high for his pastures.

It has been noted that the pastures on this farm have changed from being "clover dominant" to a nice blending of grasses and trifoliums. Perennial rye, cocksfoot, prairie, with other spring and summer annuals, are now more than 50 per cent. of the total pasture An extraordinarily vigorous growth of the so-called "Tongala wild white clover," commonly seen throughout the older pastures, has made wonderful headway. A large-framed Friesian-Shorthorn grade cow is being carried to each £70 of farm value. Without any age allowance, the butter-fat average of the herd, which was not fed any concentrates, was 354 lb. Twenty of the 30 head were under four years of age at the beginning of the testing year.

Mr. M. D. Aitken, of Ballendella, has an unusually fine little farm of 30 acres, exclusive of his small orchard. His herd consists of fifteen milking cows, and, in addition, there are a bull and young stock. Nearly £50 worth of surplus hay was sold during the year, leaving ample reserves. From two to three bags of superphosphate are used on the pastures and lucerne paddocks. Mr. H. J. Rix also scored well in this section.

Absence of weeds and the quality of the pasture in every paddock are taken into consideration by the judges. All competitors used some form of fertilizer, superphosphate being the commonest. On fifty-two farms, at least a bag per cow is used, while more than two bags are used in some instances. Of the 59 farms in the competition, 31 showed a return of more than £20 per £100 of farm value. The highest return was £56, and the lowest £9 5s.

Summary of 1933-34 Competition.

Probably the outstanding value of the competition has been the spread of knowledge through the field days that have been held on

upwards of 150 farms, mainly those of the leading competitors of the competition.

Farm areas varied from 30 to 670 acres. Twenty-two were of less than 100 acres; fifteen were of more than 200 acres. Acre values varied from £7 to £50. Thirty-four of the competing farms were valued at over £20 an acre; fourteen of them at over £30.

Capital values of the dairying areas of the farms ranged from £1,001 to £6,700; eighteen farms exceeded £3,000.

Subdivision of competing farms has been greatly developed, some farms having between 20 and 30 paddocks. In lay-out of farm, 60 per cent. of the entrants scored over 90 of the possible 100 points in this section. A noticeable weakness on many farms was the lack of sufficient shade and shelter for stock. Twenty farms scored over 90 per cent. of the possible points for a stock and domestic water supply; while 23 in the book-keeping section, and 25 in the "home section" also scored 90 per cent. of the possible points.

In the section for dairy sheds, yards, &c., 30 of the entrants scored 90 per cent. of the full points, as did also 22 in the actual milk storage and control section.

Thirty-three competitors purchased more than £20 worth of fertilizer or lime. Fifty per cent. fed over £30 worth of concentrates; fourteen used no concentrates. The highest amount spent by any one competitor on concentrates was £228. The highest feed cost was associated with the highest dairy returns. Thirteen farms purchased some hay or roughage, the majority being irrigation farmers, although from one farm £50 worth of hay was sold. More than £50 was spent on water charges on each of four irrigation farms.

Thirty-three entrants earned over £400 for dairy produce; in sixteen cases the amount was over £600. The lowest return from any farm was £135, the highest £1,631.

In the pig section, seventeen entrants had pig returns exceeding £100. That of Messrs. Batten and Sons was £457; Mr. R. Flegg's receipts were £410.

Mr. M. D. Aitken's poultry returns exceeded £100; in eight other cases the amount exceeded £20.

Fodder reserves, particularly ensilage, are receiving more consideration on the competing farms than was originally the case, while the work of improving pastures is steadily progressing.

The four competitions that have now been held have brought into being a friendly rivalry between competitors in the different zones, and the methods by which prize-winners have been successful will provide an example to all the farmers of their districts.

Dairy Herd on pastures at Mr. J. B. Watson's farm at Shepparton North.

Tomato Investigations

Results of Bendigo Tests

By A. G. Strickland, M.Agr.Sc., Horticultural Research Officer

IN a previous report (5) reference was made to a series of fertilizer and variety trials with tomatoes, which were conducted on the property of Mr. D. Danson at Kangaroo Flat. Principally owing to the extensive and variable incidence throughout the experimental field of several tomato diseases, the fertilizer trials yielded no conclusive information. The variety trial demonstrated the relative prolificacy and resistance to disease of a number of leading tomato varieties, and two strains, known as Large Red and Pale-leaf, were shown to be more resistant to disease, and of higher yielding capacity than other tested varieties. These two strains are widely planted in the Bendigo Valley.

General view of the plots.

Detailed observation in regard to diseases showed that they constituted a serious problem in the district, and were definitely the major limiting factor to increased production. An analysis of the relative importance of the various types of disease indicated the direction in which prevailing practices should be improved or altered in order to bring about improvement in yields.

The experimental work during the 1930-31 season, and in subsequent years, was modelled with a view to determining the effect of various cultural practices on the incidence of pests and diseases, and on yield generally. The influence of staking, spraying, and dusting on yield, earliness, and size of fruit has constituted a major project in the field programme, but minor experiments have been included from time to time. In order to simplify the presentation of data, the various projects have been roughly classified, although such distinction between the various phases of the work is more or less arbitrary.

I.—Staking, Spraying, and Dusting Experiments, 1930-31 and 1931-32.

In view of the serious losses occasioned by the tomato moth and other noctuids in previous seasons, it was decided that field control of these pests should be investigated. In 1929, the staking of plants definitely enabled better control of grubs, and in 1930 the experiment was designed to determine what advantage staked plants actually had over unstaked plants in this respect. At the same time, it was considered that a study of the effect of staking on total yield, size of fruit, and earliness of cropping would assist in settling the district controversy in regard to the desirability of staking.

The general lay-out of the plots was similar in both seasons under consideration, and embraced the following treatment:—

Staked.	*Not Staked.*
1. Sprayed.	5. No other treatment.
2. Dusted.	6. Sprayed.
3. Poison baits laid.	7. Dusted.
4. No other treatment.	

In 1931-32, treatment No. 3, which formerly involved the laying of poison baits, was replaced by a treatment consisting of bi-weekly dustings with a nicotine-sulphur dust. This latter treatment was designed to determine whether thrips and other sucking insects could be controlled sufficiently to decrease the incidence of spotted wilt.

Lay-out of Plots.

A plot unit of 36 plants was utilized in 1930-31, and in 1931-32 this unit was increased to 54 plants; a double guard row separated each plot from neighbouring plots. The randomized block method of replication was used, there being six blocks, each block containing one plot of each of the seven treatments; the position of each plot treatment within blocks was determined at random.

In the 1930-31 series, the plots were laid out on a portion of the field, which was used for variety trials in the previous season. The area was ploughed and graded some years ago, was under grass for three years, and had grown tomatoes for only one year previous to 1930. In this preceding year (1929), the area received complete fertilizer at the rate of 10 cwt. superphosphate, 3 cwt. sulphate of potash, and 3 cwt. sulphate of ammonia per acre. Comments on the soil of this area will be found in the 1929 report (5).

In 1931, concentration of diseases rendered it necessary to choose a new site, and the plots were laid out on a neighbouring field, which had been under grass for many years. Systematic soil-sampling of this area showed the soil to be of a similar nature to that on which the experiment was formerly situated. This new area had received no differential manuring previous to laying out the 1931-32 plots.

In each season the soil was brought to perfect tilth by means of several deep ploughings, and repeated harrowing and cultivation.

The plants were all raised from selected seed in steam-sterilized soil, in sterilized trays. They were later pricked out singly at even distances apart in fresh trays, all weak seedlings being culled during pricking out. Further heavy culling was practised during the setting of plants in the field, and in each season an exceptionally uniform stand of vigorous healthy plants was obtained. A strain of Large Red, locally known as "Pale-leaf," was used, owing to its suitability to the Bendigo district, and wide popularity.

The trays containing the young plants were taken to the field, and each plant removed and set with as much soil attached to the root system as was possible. According to local practice, each was covered with a sprig of scrub in order to protect it from possible frosts. Setting in the field was carried out about the third week in October.

The whole area received a base dressing of superphosphate 6 cwt. per acre, and sulphate of potash 3 cwt. per acre, distributed in furrows along the rows. In both seasons, nitrogen was withheld until the first crop of fruit was swelling, when sulphate of ammonia was applied at the rate of 3 cwt. per acre.

The plants were watered at intervals of one to two weeks, according to weather conditions, by means of short furrows (20 feet long) running between the plant rows.

Where necessary, plants were tied to stakes as their growth warranted, and pruned to several stems.

Spraying and Dusting.

Spraying was carried out at fortnightly intervals, using 1 lb. of arsenate of lead paste per 20 gallons of water. A 50 per cent. arsenate of lead dust was applied to the appropriate plots at similar intervals. In 1931-32, nicotine-sulphur dust was applied to the appointed plots twice weekly.

Observations.

Fruit was picked once or twice a week according to the rate of ripening, and graded into the three market sizes (under 2 inches, 2 to 3 inches, and over 3 inches), the weight of fruit in each grade being determined. In 1930-31, the number of fruits also was recorded, but as this figure was considered unnecessary, it was not obtained in subsequent seasons. A count of all grub-affected fruit was made.

In 1930-31, the first picking was made on 19th January, and the last picking on 9th May; in 1931-32, the first and last pickings were on 7th January and 2nd May respectively.

Periodic notes on the health of plants, and the incidence of disease were made from time to time.

EXAMINATION OF RESULTS.

(*a*) *The Control of Tomato Moth.*—In order to ensure a source of infection with tomato moth in 1930-31, the experimental block was "sown" with pupae obtained from a heap of tomatoes discarded by a grower in

another part of the district, during the previous season. This attempt at artificial infection was considered advisable in view of the very light infection of the previous season's crop on the experimental field. Despite these efforts, the moth did not cause any serious loss of fruit in 1930-31, or in any subsequent season. The district, as a whole, has not experienced in the past few years an infestation of tomato moth comparable with that of 1929-30. Nevertheless, various plantations have experienced appreciable losses in recent seasons, and it is undoubted that the use of good cultural methods on the experimental field has contributed towards its freedom from tomato moth.

In both seasons under review, the percentage of grub-infested fruit was only a fraction of 1 per cent. of the total crop. Consequently, one objective of the experiment, i.e., to determine the effect of the several treatments on grub infestation, was defeated.

(*b*) *Effect on Yield, Earliness, and Size of Fruit.*—It has already been noted that the experiment was laid out in six blocks, each of seven treatments being allotted to one plot in each block. In Table I., the yield for each treatment is shown as an average of the yields of the six replicate plots. All field experiments are subject to some unavoidable error, and in order to be sure of our conclusions, we must take this error into account when examining the results. The manner in which these plots have been laid out has enabled statistical determination of unavoidable error, and the computation of a figure which appears in the last column of Table I. This figure is termed the "Significant Difference," and differences between any two of the averaged yields in the table which are greater than the significant difference figure may justifiably be attributed to the differential treatment. On the other hand, any differences which are smaller than the significant difference may be regarded as unreliable, and not necessarily due to differential treatment. For the sake of easy comparison, the yields have been presented also in terms of cases per acre, and as a percentage of the general average (or mean) yield of all the plots. The data contained in Table I. are shown graphically in Figure 1.

Examination of Table I. and Figure 1 shows that the average yield over the whole area was at the rate of 775 cases per acre in 1930, and 771 cases per acre in 1931, while the "significant differences" were 187 cases per acre, or 24 per cent., and 118 cases per acre, or 15 per cent. respectively. This decrease in significant difference denotes a reduction in error, and may possibly be ascribed to the fact that spotted wilt was more even in its incidence in the latter season. Further reference to disease will be made in another section of this report, but it is necessary to note here the possible bearing of spotted wilt infection on the variability of the experimental material. Careful counts showed approximately 40 per cent. of all plots in the experiment to be wilt infected in 1930-31, and, as would be expected, the wilt-affected plants were scattered indiscriminately throughout the area—a large number in some plots, and fewer in others. This state of affairs would tend to increase the

TABLE I.

—	—	Not Staked.			Staked.				General Mean.	Significant Difference.
		Sprayed.	—	Dusted.	Dusted.	Sprayed.	—	Poison Baits.		
1930–31	Mean yield per plot (lb.)..	201	206	215	198	210	198	203	205	49
	Cases per acre	760	779	813	748	794	748	767	775	187
	Percentage of general mean	98	101	105	96	102	96	99	100	24
1931–32	Mean yield per plot (lb.)..	388	339	331	289	273	261	263*	306	47
	Cases per acre	978	864	831	728	688	658	663*	771	118
	Percentage of general mean	126	110	108	94	89	85	86*	100	15

* Poison bait treatment replaced by nicotine sulphur dusting treatment in 1931-32.

unavoidable error of the experiment, and as we have seen, the significant difference was high—24 per cent.

In 1931-32, however, the spotted wilt infection closely approached 100 per cent. This extensive infection made for more even conditions throughout the area, and for a decrease of unavoidable error, reflected in the lower figure of 15 per cent. for significant difference. Although we are not considering 1932-33 figures at present, it may be pointed out here that, in this year (1932-33), the wilt infection was of the same order as in 1930-31—approximately 36 per cent.—and, as would be expected from the above reasoning, the significant difference was again high—21 per cent. These facts illustrated the overwhelming importance of spotted wilt in the Bendigo district. Further consideration of the question will be given in another section of this report.

Table I. and Figure 1 disclose that in no case in 1930-31 was there a significant difference between two treatments. The conclusion is that staking has not influenced total yield in any direction, nor have spraying or dusting had any notable effect on cropping.

The 1931-32 figures, however, fall into two distinct classes, the unstaked plots having in every instance yielded significantly higher crops than the staked plots. Moreover, under unstaked conditions, the sprayed plots have outyielded the dusted plots, and those plots receiving neither spray nor dust. This superiority of the sprayed plants is not borne out under staked conditions, and is difficult to explain. The grub infestation was negligible, and offers no explanation of the facts. It is suggested that the mechanical shielding and shading effect of the white spray material may have had some ill-defined influence.

The outstanding feature of the yield figures is the fact that, in 1930-31, staked and unstaked plants yielded equally well, whereas in 1931-32 the unstaked plants gave a significantly higher total yield than the staked plants. Now in 1930-31, 40 per cent. of plants were affected with spotted wilt, while in 1931-32 practically 100 per cent. were affected. Unfortunately progressive counts of wilt infection were not made during the early part of the season, but general observations point to the probability of earlier infection in 1931-32. This is supported by the data in regard to early fruit, which is presented in Table II., and which is discussed in the next section of this report. Bald and Samuel (1) have demonstrated the feasibility of mechanical inoculation of healthy tomato plants with spotted wilt, by means of the juice of young plants recently infected. In a year favorable to early appearance of spotted wilt, such as 1931-32, the frequent handling of staked plants necessitated by pruning and tying up could quite conceivably result in mechanical transfer of

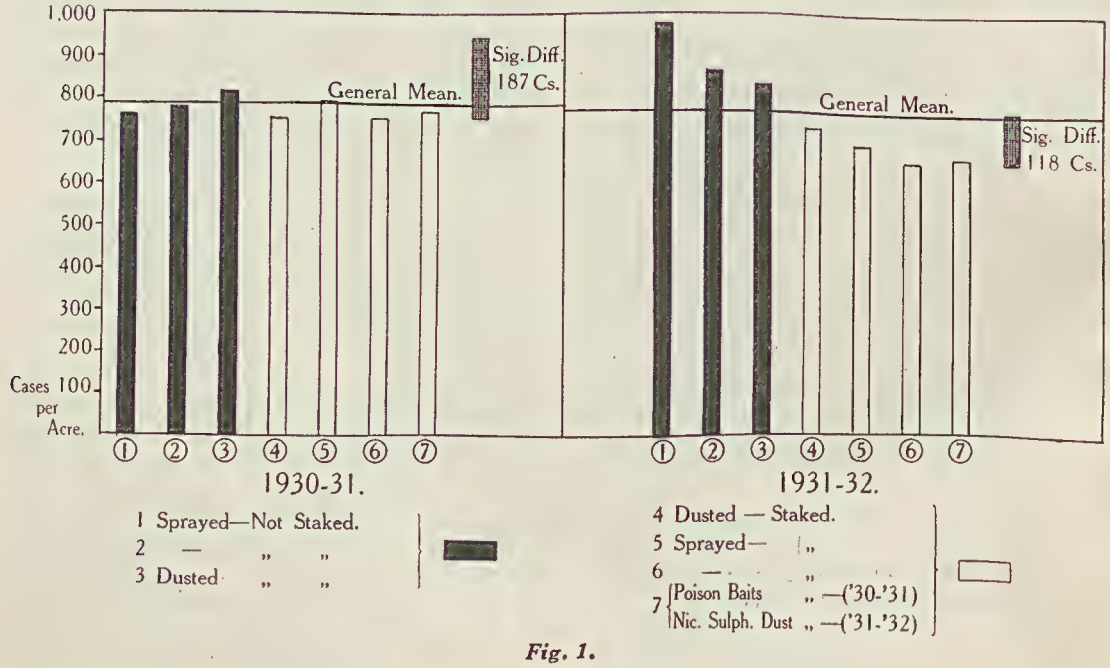


Fig. 1.

TABLE II.—EFFECT OF TREATMENTS ON EARLINESS.

		Not Staked.			Staked.		
		Sprayed.	Nil.	Dusted.	Sprayed.	Nil.	Dusted.
		lb.	lb.	lb.	lb.	lb.	lb.
1930–31	Weight of fruit in first four pickings ..	39	33	33	29	33	31
1931–32	Weight of fruit in first five pickings ..	36	37	43	28	25	25

the disease at a faster rate than would be the case with unstaked plants, which receive practically no handling. If such were the case, we would expect reduction of yield under staked conditions, and in 1931-32, the year in which spotted wilt was so troublesome, there was a modicum of evidence to support this possibility.

The effect of the various treatments on earliness of cropping is sumarized in Table II.

The figures in Table II. show that in 1930-31 there was no difference in earliness between staked and unstaked plots. In 1931-32, there appears to be more early fruit from the unstaked plants than from the staked plants —the reverse of the generally accepted rule. Actually, this early advantage of unstaked plants in 1932 was maintained throughout the season, resulting ultimately in a higher yield under unstaked conditions. Although former experiments in many parts of the world have shown that staking and pruning tend to depress total yield, it has been the general contention that staked conditions make for earlier fruit. This has not been borne out under the conditions of this experiment, for in one year there was no tendency to mature earlier fruit as a result of staking and pruning, and in the following year the staking actually resulted in a reduction of early fruit. A possible explanation of this has been referred to earlier in the report, i.e., the likelihood of spreading spotted wilt rapidly in pruning and tying up, thus depressing the yielding capacity of the plants from a very early stage.

The effect of various treatments on size of fruit is shown in Table III. In this table, an estimate of fruit size was arrived at by two different methods. In 1930-31, the total number of harvested fruits was recorded, and the average fruit size was obtained by dividing the total crop weight by the number of fruits. In 1931-32, no count of fruits was made, and in order to determine whether treatment had affected size of fruit, the percentage weight of fruit in each of the three market grades was determined for each treatment.

It is evident from the figures in Table III. that none of the treatments had any marked effect on the size of fruit in either season. Staking and pruning are reputed to increase fruit size, but under the conditions of this experiment such was not the case.

SUMMARY OF RESULTS (1930-31 AND 1931-32).

1. Grubs were not sufficiently troublesome in either of these seasons to enable any con-

TABLE III.—EFFECT OF TREATMENTS ON SIZE OF FRUIT.

		Not Staked.			Staked.		
		Sprayed.	Nil.	Dusted.	Sprayed.	Nil.	Dusted
1930–31	Average weight of single fruit (lb.) ..	0·15	0·15	0·14	0·15	0·15	0·15
1931–32	Percentage of fruit: Under 2 inches ..	51	57	58	52	55	55
	Percentage of fruit: 2 inches to 3 inches ..	31	27	29	31	30	31
	Percentage of fruit: Over 3 inches ..	18	16	13	17	15	14

clusions to be drawn as to the effect of staking, spraying, and dusting on their control. It is certain, however, that arsenical spraying or dusting in a thorough fashion would give a good measure of control, and even more so when plants are staked, owing to the possibility of more efficient spray or dust coverage under staked conditions.

2. In 1930-31, there were no significant differences in yield or earliness between staked and unstaked plots, whereas in 1931-32 the staked plants were significantly lower yielding of both early and total fruit. It may be inferred that staking and pruning give no advantage in regard to earliness or total yield, and may, in certain seasons, definitely reduce the yield of early fruit, and also of total fruit.

3. In neither season did staking or any other treatment affect the average size of fruit.

II.—Staking and Pruning Experiments in 1932-33.

In view of the fact that staking did not have any marked effect on yield or earliness in one season, and definitely reduced both the production of early fruit and the total yield in the following season, a further series of plots was laid out during 1932-33. These plots were located on portion of the area used in the previous season, and comprised the following treatments:—

Not Staked—

1. Pruned; no nitrogenous fertilizer.
2. Pruned; December dressing of sulphate of ammonia.
3. Not pruned; December dressing of sulphate of ammonia.
4. No treatment whatever.

Staked—

5. Pruned; no nitrogenous fertilizer.
6. Pruned; December dressing of sulphate of ammonia.

The above treatments were designed to show the effect of staking and pruning, the effect of pruning unstaked plants, and the effect of withholding nitrogen. The lay-out was of the randomized block type, there being six blocks in all, and as in 1931-32, a plot unit consisted of 54 plants. Plants were raised and set out as in previous years.

The whole area received a mixture of superphosphate (4 cwt. per acre), and sulphate of potash (2 cwt. per acre) at planting time. In the case of treatments 2 and 6, the appropriate plots received sulphate of ammonia at the rate of 3 cwt. per acre on 20th December.

Staked plants were pruned to two or three stems, and in the case of treatments 1 and 2, the unstaked plants were lightly pruned in the early part of the season with the object of removing lateral growths as they appeared in the leaf axils. As a precaution against tomato moth, the whole area was dusted periodically with a 50 per cent. arsenate of lead dust.

The fruit was picked, and yields recorded as in previous years, the first picking occurring on 10th January, 1934. Periodical observations on the incidence of disease were carried out as formerly.

The yield figures are presented in Table IV., and it will be noted that the total yield throughout all plots is higher than in 1930-31 or 1931-32. This higher average yield may be due partly to the lower level of spotted wilt infection—approximately 36 per cent.—and perhaps also to the residual effect of

Table IV.

—	—	Not Staked.			Staked.			General Mean.	Significant Difference.
		Pruned.	Pruned. Sulphate of Ammonia.	Sulphate of Ammonia.	—	Pruned.	Pruned. Sulphate of Ammonia.		
1932–33	Mean yield per plot (lb.)..	426	401	408	507	409	420	428	88
	Cases per acre	1,074	1,011	1,028	1,278	1,031	1,058	1,079	222
	Percentage of general mean	99	93	95	118	95	98	100	21

fertilizers applied on this area in the previous season. As before, grub affected fruit was negligible in the case of all treatments.

The yield figures, when examined in conjunction with the significant difference—222 cases per acre, or 21 per cent.—show that staking, pruning, or the application of sulphate of ammonia does not appear to affect the cropping. The yield figures are all clustered about the same level, with the exception of one treatment series. The series of plots receiving no pruning or staking treatment, and no sulphate of ammonia, have significantly out-yielded all other plots. It would seem that the application of sulphate of ammonia tends to decrease total yield. A satisfactory explanation for this is difficult, unless we suppose that the nitrogenous fertilizer encouraged a vegetative condition at the expense of fruit. If this were so, we would expect pruning to partly overcome such an effect, but it is obvious from Table IV. that pruned plants have all yielded on a lower level, whether receiving sulphate of ammonia or not.

The general conclusion may be drawn that none of the separate treatments, nor any combination of them, has resulted in better cropping than is the case with plants unpruned, unstaked, and not receiving sulphate of ammonia, Owing to the fairly heavy dressing of sulphate of ammonia (3 cwt. per acre), applied to this area in 1931-32, the lack of response to nitrogen was not unexpected.

The percentage of the total yield of fruit comprising each of the three market sizes, and the average weight per plot of early fruit in the case of each treatment is shown in Table V.

It will be seen from this table that there has been no material difference in fruit size under the various treatments.

Although pruning seems to have induced a slight increase in the production of early fruit from unstaked plants, this increase is hardly significant, and we can generally conclude that staking and pruning have not markedly encouraged earliness.

General Conclusions.

The results of these field experiments have suffered from the interaction of other factors, such as variable incidence of spotted wilt in successive years, but they clearly indicate that staking and pruning of tomato plants are of little value under Bendigo Valley conditions. Staking and pruning did not induce earlier fruiting, did not materially affect the average size of individual fruits, and, if anything, tended to decrease total yield. In one season out of the three, staked plots yielded at the rate of 100 to 200 cases per acre less than did unstaked plots.

Table V.—Showing Effect of Treatment on Average Size of Fruit, and Production of Early Fruit.

1932-33.	Not Staked.				Staked.	
Percentage of Fruit.	Pruned.	Pruned. Sulphate of Ammonia.	Sulphate of Ammonia.	——	Pruned.	Pruned. Sulphate of Ammonia.
	%	%	%	%	%	%
Less than 2 inches	48	53	54	46	46	45
2 inches to 3 inches	35	33	30	35	37	37
Over 3 inches	17	14	16	19	17	18
Early Fruit.	lb.	lb.	lb.	lb.	lb.	lb.
Weight of fruit per plot in first four picks ..	29.8	21·5	23·6	24·0	18·3	24·1

It is undoubted that tomato moth and other noctuid pests of tomatoes may be controlled with greater ease if plants are staked, but with ordinary care, bad grub visitations occur only very infrequently, and the question of their control does not influence the decision that staking is inadvisable.

The pruning of unstaked plants with the object of inducing earlier fruiting is of doubtful value, and owing to the possibility of spreading virus diseases, such as spotted wilt, through such pruning, it is considered that plants should be left unpruned.

Staking and pruning methods should be limited to home gardens or other situations where it is desirable to plant at short distances owing to limitation of area.

Method of shading plants.

III.—Disease Investigations.

(A) Spotted Wilt.

Owing to the fact that the Council for Scientific and Industrial Research was carrying out comprehensive investigations in regard to this disease, the work at Bendigo was confined to general observations and attempts at field control. The serious nature of this disease, and the variation in its severity from season to season are shown by the percentages of plants affected in three successive seasons, viz., 40 per cent., 100 per cent., and 40 per cent. The high rate of infection which occurred in 1931-32 was accompanied by a general blotching and mottling of all fruit harvested. This blotching was very prevalent throughout the Bendigo district in 1931-32, and was a matter of some concern to tomato pulp manufacturers, hindering as it did the production of highly coloured pulp. In the preceding and succeeding seasons, this type of blotching was not common, even in the case of fruit borne by plants affected with Spotted Wilt. The trouble has not yet been definitely connected with Spotted Wilt, and mottled fruit may be borne by plants showing no other definite symptoms of Spotted Wilt, or diseased plants may bear fruit which is not mottled. Bald and Samuel are engaged in infection experiments which should ultimately establish the relation between this mottling and Spotted Wilt.

Variety Tests.—Observations on the resistance of a number of varieties to Spotted Wilt were continued in 1930. As in the previous season, round, smooth-skinned varieties, especially those of American origin (such as Norton and Marglobe), showed marked susceptibility to Spotted Wilt. The most resistant varieties were the locally popular "Pale-leaf" and South Australian Dwarf Red.

Dusting Experiments.—Field control of Spotted Wilt has been attempted from time to time, but usually such attempts have given negative results.

It has been shown (4) that various sucking insects, notably two species of thrips, *Frankliniella insularis,* and *Thrips tabaci,* are definitely able to transmit Spotted Wilt from plant to plant. A comparatively small number of thrips may be responsible for the infection of many plants, and the possibility of indirectly controlling the disease by means of controlling sucking insects is remote. Spraying or dusting with the usual contact insecticides would have to be exceedingly thorough, and very frequent to serve any good purpose. Despite these manifest difficulties, it was thought that the efficacy of a nicotine dust should be investigated. A proprietary thrips dust containing 90 per cent. sulphur and 10 per cent. free nicotine was applied at intervals of three days on one series of plots in the 1931-32 experiment. During the same year a number of plots received dustings of elemental sulphur at weekly intervals. Neither the biweekly nicotine-sulphur dusting, nor the weekly sulphuring, resulted in any variation in the incidence of Spotted Wilt, general health, and vigour of the plants or yield.

Shading Experiments.—Investigations in America on the subject of "Tomato Yellows," a serious virus disease, have shown that partial

shading of the plants with temporary tents was efficacious in reducing losses from this disease. The tents were directly effective in partially protecting the plants from visits of leaf-hoppers (*Eutettix tenellus*), which are responsible for spreading the disease, but the benefit of such shading was not due solely to this factor. The actual shading seemed to have a direct effect in creating conditions less

Left.—Plant with spotted wilt. Right.—Normal plant.

favorable for development of the disease. Spotted Wilt has some points of resemblance to Tomato Yellows, and, moreover, several growers have informed the writer that protection of plants with a heavy white spraying compound seemed to mitigate the effects of Spotted Wilt. In view of this meagre evidence of the possible effects of shading, several young tomato plants were partially covered with a cheesecloth shelter shortly after setting in the field. The covered plants were distributed in three plots of twenty plants each, and interspersed with similar plots without covering. Periodical inspection and counts of wilt infection showed that shaded plants developed Spotted Wilt at the same rate as unshaded controls, and the ultimate extent of infection was as great under shaded, as under unshaded conditions.

Effect of Copper.—Some growers in the Bendigo district make a practice of inserting a small piece of copper wire through the stem of each plant when setting in the field, and claim that by so doing they decrease the liability of such plants to Spotted Wilt. In order to determine the validity of this claim, some plants were so treated during the 1931 planting. In this season, practically 100 per cent. of wilt infection occurred, and the treated plants showed no advantage over untreated in respect to Spotted Wilt. The contention was also checked under controlled conditions in the glasshouse at the Burnley Gardens. In collaboration with the Assistant Plant Pathologist (Mr. S. Fish), some pot-grown tomato plants were subjected to the copper wire treatment. Other plants were irrigated with very dilute solutions of copper sulphate, and attempts were made to inject very dilute copper solutions into the stems of growing plants, according to the method described by Bose (2). All plants were mechanically inoculated with Spotted Wilt by means of a technique evolved by Bald and Samuel (1). The mechanical inoculation of Spotted Wilt was successfully demonstrated, but no diminution in the infectivity of the virus was occasioned by any of the above-mentioned treatments.

(B) Root Diseases.

In a previous report (5) it was stated that towards the end of their bearing, practically every plant in a field experiment at Bendigo showed typical symptoms of root disease. Pathological examination of affected plants showed the presence of several fungi, but it was evident that the symptoms could be attributed mainly to "Black Dot," a root disease caused by the fungus *Colletotrichum* sp. Although the majority of plants were comparatively unaffected by this disease until towards the end of the season, approximately 10 per cent. were either killed or rendered unproductive early in the season.

In order to definitely link this root rot disease with the Black Dot fungus, controlled infection experiments on pot-grown plants were conducted in conjunction with Mr. Fish. A pure culture of *Colletotrichum* was propagated on sterilized barley husks, and the infected husks so obtained were scratched into the surface soil of large pots containing growing tomato plants. These plants were grown to an advanced stage, and in due course developed symptoms of root rot which were identical with those exhibited by field plants at Bendigo. Control plants which received sterile husks, instead of infective husks, developed normally.

In this way it was demonstrated that the *Colletotrichum* fungus found on the roots of plants at Bendigo is definitely capable of producing the typical root rot disease so commonly present in the field.

A species of *Colletotrichum* has been identified by Fish as associated with a damping off disease of tomato seedlings, and this worker has demonstrated that the disease may be

effectively controlled by careful sterilization of seed boxes and equipment, and steam sterilization of the soil used for raising seedlings.

Although it has not been finally established that the *Colletotrichum* causing root rot in the field at Bendigo, and that causing seedling

Plant affected by Black Dot disease towards the end of the season.

disease in the nursery are identical, it is suspected that such is the case. In this event, it is apparent that the seed bed or seed boxes may very easily constitute a centre for the infection of plants. The disease, as it occurs in the field, is slow in its development, especially under high temperatures and under irrigated conditions, and rarely affects plants noticeably until they have been weakened somewhat through bearing.

In order to ascertain the extent to which seed bed infection could be held responsible for widespread occurrence in the field, a small trial was carried out at Bendigo. "Pale-leaf" seedlings raised in unsterilized soil, and exhibiting mild symptoms of the seed bed trouble, associated with *Colletotrichum,* were planted side by side with a similar batch of plants grown in sterilized soil, and showing no sign of root disease. The land on which these batches were planted had never grown tomatoes previously.

The infected plants of the unsterilized soil batch were reasonably sound and well-grown plants from a commercial stand-point, but on close examination some of them showed slight signs of infection on the roots and round the collar. The planting consisted of three sections, viz., healthy plants (200), unhealthy plants affected with "collar rot" (100), and unhealthy plants affected with "root rot" (100). The three batches developed normally after setting in the field, and except for the contraction of Spotted Wilt, showed no immediate signs of disease. Spotted Wilt did not cause the death of any plants, but interfered considerably with the cropping of individuals. The infection with Spotted Wilt was approximately equal in the three sections, viz., healthy seedlings 49 per cent., seedlings with root rot 53 per cent., seedlings with collar rot 58 per cent.

No symptoms of root disease were evident in any section until the beginning of February, at which period many plants showed the yellowing and withering of lower leaves characteristic of root trouble. These symptoms gradually involved the whole of the plants concerned. A count of affected individuals was made at the end of February, and resulted in the following:—

Healthy seedlings planted—20 per cent. of mature plants affected with root disease.

Seedlings with root rot planted—53 per cent. of mature plants affected with root disease.

Seedlings with collar rot planted—48 per cent. of mature plants affected with root disease.

It is evident that the proportion of affected plants at the end of February was considerably higher in the sections which were supplied with questionable seedlings, grown in unsterilized soil. The advantage of healthy seedlings is immediately apparent when it is realized that those plants which were showing the symptoms at the end of February were definitely finished from a cropping stand-point. Such an early completion of the cropping life of a large number of plants is a serious matter in a district where the sale of late crops to pulping factories is an important adjunct to the earlier market trade.

From the end of February until the completion of the season early in May, root disease

gradually involved nearly all the plants in each section, and ultimately there was practically the same amount of infection in all sections. At the completion of the season, plants were pulled out and the roots examined. Every plant in each of the three sections showed black sclerotes of the *Colletotrichum* fungus, and more or less rotted roots.

It may be concluded from this trial that, under Bendigo conditions, sterilization of seed bed soil, and the planting of none but vigorous healthy seedlings will not preclude the ultimate development of Black Dot disease, especially where the soil is contaminated with a carry-over from previous seasons. It will, however, help to prevent early inroads of the disease which may occur when plants have been exposed to infection in the seedling stages. In view of the pulping trade in late tomatoes, it is important that the development of Black Dot should be delayed as long as possible in cases where it is troublesome.

(c) Blossom End Rot.

It is generally held that this disease is due to exposure of plants to temporary drought conditions, while fruits are ripening. Although the plants may not show any of the usual symptoms of water shortage, the leaves may lose water at a faster rate than the roots can supply it; under such conditions, it is supposed that water is withdrawn from the fruits, with consequent death of cells at the base of the fruit. A round sunken patch of dead tissue develops at the end of the fruit.

This disease is regularly responsible for minor losses in the Bendigo district, and occasionally some growers sustain considerable damage. In order to determine the effect of irregular watering and temporary drought on the incidence of Blossom End Rot, triplicate plots were laid out, three plots being watered at the judgment of the grower, and three plots being deprived of every second irrigation. Owing to the lateral movement of water from neighbouring plots, those plots which received every second watering only were not parched to a serious extent. Nevertheless their water supply was sufficiently interfered with to approximate to the conditions which are considered to favour the occurrence of Blossom End Rot. The yields of sound fruit, together with the percentage of fruit affected with Blossom End Rot, are shown in Table VI.

Table VI.—Showing the Effect of Irregular Watering on Blossom End Rot.

Treatment.		Yield (lb).	Number of Fruits.	Percentage of Fruits with Blossom End Rot.	
Watered regularly ..	1	106	752	0·6	0·6
	2	107	690	0·4	
	3	135	983	0·7	
Every second watering omitted	1	60	423	3·2	4·1
	2	71	543	6·5	
	3	94	721	2·3	

It will be noted that not only did irregular irrigation increase the incidence of Blossom End Rot, but also resulted in a reduction in total yield. Whereas the average yield per plant on fully watered plots was 6.5 lb., it was only 4.2 lb. on irregularly watered plots. This reduction in yield was not due to smaller fruit, but to an actual reduction in the number of fruits per bush, and was presumably the result of poor setting. Although the amount of Blossom End Rot was not unduly high in any case, it was definitely and consistently higher where irrigation was spasmodic, and we may justly conclude that marked fluctuations in water supply tend to favour the incidence of this disease. Furthermore, such interference with water supply limits the bearing power of the plants.

Black Dot Disease. Left.—Healthy plant. Right.—Diseased plant.

IV.—Investigations on Plot Technique.

In order to establish a satisfactory basis for field experiments with any crop, it is desirable to know something of the variability of the material to be dealt with, and of the inevitable errors due to this variability. Having this information, it is possible to formulate the best size of plot, and the number of replications of a single treatment plot necessary to enable us to obtain a valid estimate of the error of the experiment, and of the significance of differences in yield between differentially treated plots.

A survey of the literature has disclosed no definite information of this nature in respect to tomatoes, and in any case, it is doubtful if variability of figures obtained in other localities would apply to Bendigo conditions, where the effects of Spotted Wilt induce great variability in yielding power from plant to plant.

To obtain data in this regard, a uniformity trial was conducted during 1932-33 on a patch of 1,080 plants. The results of this trial will be reported elsewhere, and it will be sufficient to state here the bald conclusions.

The optimum plot size was shown to be in the region of 36 plants distributed in this case as two rows of eighteen plants each. The coefficient of variability of a plot of this size is approximately 10 per cent., and from Hoblyn's table (3) it will be seen that, using this sized plot under similar conditions to those at Bendigo in 1932-33, nine replicated plots of each treatment would be necessary to prove 10 per cent. differences between treatments. Larger differences of the order of 20 per cent. could be shown with four replications of an ultimate plot. It is interesting to note that in the absence of this definite information, a plot unit of 36 plants was used in the 1931-32 field experiments at Bendigo, and as six replications were employed, it would have been possible to demonstrate differences between treatments of the order of about 15 per cent.

General Summary.

1. Owing to the negligible losses through "Tomato Moth" over the whole area in the three seasons under review, no definite conclusions regarding the efficacy of staking, spraying, or dusting in combating this pest were possible.

2. Staking and pruning, or the pruning of unstaked plants are of doubtful value, except on limited areas, and are not recommended for typical Bendigo plantings.

3. An account is given of observations and investigations on the control of Spotted Wilt, Black Dot Disease, and Blossom End Rot. Control measures are indicated for the two latter diseases.

4. A uniformity trial was carried out during 1932-33, and the conclusions in regard to plot technique for tomato field experiments are recorded.

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The Codling Moth

(*Carpocapsa pomonella L.*).

By R. T. M. Pescott, M.Agr.Sc., Entomologist.

THE apple and the quince were among the first of the present-day commercial fruits that were cultivated in Europe. The codling moth, in all probability, originated in South-western Europe, where the majority of these earlier trees were planted. We find evidence of this in the writings of the early Romans, where we read of "wormy" apples, statements which undoubtedly refer to the codling moth. However, it is unlikely that the codling moth was a really serious pest with these early growers, because, from a knowledge of the horticulture of the period, we know that the apple trees were small, smooth-stemmed, and well looked after. Under these conditions, those codling grubs that left the apple succumbed to the attacks of birds and to insect parasites, both external and internal. Those that remained in the fruit also usually were destroyed, because, since the areas planted with apple trees were small, it was necessary that every apple (even those that fell) be collected, crushed up, and (grubs included) converted into cider. Thus, there was little or no waste, and the codling moth was held in check.

With the advance of civilization, and the planting of apple trees in large blocks or areas, notably in America, South Africa, and Australia, the whole system of cultivation was altered. Waste fruit that fell from the trees was not considered worth-while gathering while hundreds of cases of good, sound fruit were hanging on the trees. Consequently, the codling moth gradually gained ground, until to-day it is the major pest with which the fruit-grower in all parts of the world has to contend.

The codling moth was accidentally introduced into Australia from England by the earliest settlers, either in produce or on nursery stock, and the first two States in which it became established were New South Wales and Tasmania. In Victoria, the earliest authentic record of the codling moth is in 1855, but, without doubt, it was present many years before then. In South Australia it was not until 1885 that it was first seen, while in 1874 it appeared in New Zealand, apparently being brought there from Tasmania. Of the Australian States, Western Australia is the only one in which a successful attempt has been made by rigid quarantine measures to keep the insect out.

Fig. 1.—"Sting" caused by newly-hatched larva of codling moth.

Nature of Injury.

The codling moth larva or grub is an internal feeder. By far the greatest injury is done to the inside of the fruit, little indication of the internal havoc being revealed by a casual examination of the exterior. As a rule, the young grub feeds for a short time near the surface, later working its way to the centre of the fruit, where it devours the core tissue and some of the seeds, leaving an unpleasant mass of excrement in their place. An apple affected at an early stage will fall prematurely, but fruit attacked at any stage is rendered unfit for marketing.

A type of injury frequently found on sprayed apples is known as a "sting." This occurs when a young grub is poisoned in its attempt to enter the fruit. A small hole up to a quarter of an inch in depth is left, and as this is frequently made more conspicuous by the development of colour around the spot, and by its enlargement due to the entry of fungi, &c., the stinging of fruit seriously detracts from its market value.

Extent of Losses.

The codling moth is primarily a pest of apples, though at times it attacks pears and quinces almost as severely. Walnuts and stone fruits, such as apricots, peaches, and plums, also are attacked.

It is impossible to estimate with any accuracy the loss to the fruit-growing industry caused by the codling moth, but it may reasonably be taken that in an average year this pest is responsible for damage ranging from 2 to 15 or 20 per cent. of the apple crop in different districts, according to the climatic conditions, and averaging, perhaps, 5 per cent. over the whole State. This loss would amount to about 100,000 bushels, valued at over £25,000 per annum. Again, the pest is responsible for heavy expenses incurred by growers in buying and applying sprays and carrying out other treatments.

Description and Life History.

Two complete broods and a partial third brood of the codling moth usually are present in Victoria each year. The larvae or caterpillars from the last or autumn brood and the majority of the second-brood larvae spin their cocoons on the trunks or limbs, and remain as larvae throughout the winter months. These overwintering larvae commence to change to pupae or chrysalids within their cocoons from about the end of September onwards. They remain as pupae for several weeks, and then turn to the first brood of moths. The moth is small, measuring from ½ to ¾ inch across the outspread wings, which are of a general brown colour banded with grey, the hind wings being a lighter brown in colour. The most distinguishing feature, however, is the possession of a large, oval, dark-brown spot, with coppery-coloured streaks near the tip of each forewing.

A few days after emerging, the spring brood moths lay their eggs on leaves and near the small developing fruit, each moth laying from 25 to 75 eggs. From these minute, flat, whitish eggs hatch tiny caterpillars, which may feed for a time on young leaf tissue, but usually they make their way straight to the young fruit. Some of these caterpillars enter at the calyx end, but others enter elsewhere on the fruit. The caterpillars feed within the fruit for about four weeks, and then leave the fruit, spinning their cocoons on the branches or trunks of the trees. They commence to pupate in the middle of December, and continue until the end of January.

Fig. 2.—Adult codling moth, 2½ times natural size.

The moths of the second brood commence to emerge early in January, and, after about three days, commence egg-laying. The larvae hatching from these eggs, which are laid either on the fruit or on the underside of the leaves, are only about one-sixteenth of an inch in length, and they crawl around for some time to find a suitable spot at which to attack the apple. Even those which hatch out on the fruit do not bore into the apple immediately, but move about to find a sheltered spot, usually on the sides of the apple, particularly where two fruits touch, or where a leaf forms a shelter over portion of the apple.

The newly-hatched grub appears to feed for a short time near the surface of the fruit, apparently gaining strength before boring into the core, where it lives until fully grown. When this stage is about reached, the codling

bores its way to the surface, at first leaving this exit hole blocked with excrement. Later, the full-grown grub leaves the fruit by way of this tunnel, and seeks a place to make its cocoon. If the apple is still on the tree, the grub lowers itself by a thread to the ground, creeps to the trunk of the tree, and spins its cocoon among the rough bark, frequently scooping out a shallow oval cavity with its jaws. The grubs may also creep down the branches to the trunk, instead of lowering themselves to the ground. In the northern districts of the State particularly, some of these larvae turn to pupae, finally emerging as the adult moths of the third brood. This brood completes part of its life history, remaining as larvae, together with those larvae of the second brood which did not complete their metamorphosis, under the loose bark and in cracks of the tree trunk.

Control Measures.

The control measures consist essentially of processes for destroying the pest in different stages of its development. These can be considered under four distinct headings—(*a*) orchard sanitation, (*b*) spraying, (*c*) bandaging, and (*d*) the use of lures.

Orchard Sanitation.—This is by far the most important feature of codling moth control, and frequently the one most neglected by growers. The high percentage of infection in the vicinity of the fruit-houses and packing-sheds, often in spite of extra sprays, shows very clearly that sprays, however carefully applied, cannot cope with the pest unless the orchard is kept clean.

At the end of each season the orchardist should take particular care to free his packing sheds and surroundings from the codling grubs which have crawled from infested apples and made cocoons in cracks and sheltered places. The provision, whenever practicable, of moth-proof fly-wire screens over doors and windows to prevent egress of emerging moths is a simple and inexpensive method.

Cases used in transporting fruit from the orchard and all returned cases should be examined and any grubs in them killed. The best method is to dip all cases in boiling water, to every 20 gallons of which 1 lb. of washing soda has been added. Immersion for two minutes in this solution is desirable. This treatment has a double effect in that it destroys the spores of moulds and other fungi, as well as all insect pests hidden in the cases. Props and poles used in the orchard should be kept free from bark and examined for grubs. This is a very important precaution, upwards of 80 grubs having been found in one pole in an orchard quite recently.

As most windfalls are affected with codlings, they should be gathered up once a week during the apple season, and destroyed by burning or boiling, or else fed to pigs. If the apples are given to pigs, they should be fed as soon as gathered; if they are stored for any length of time, they become a hatchery for the moth. It pays also to have all infested apples picked at least once or twice during the season and treated as previously suggested.

Spraying.—The aim of every orchardist who uses spraying as a means for controlling insect pests should be to develop a spray programme which will prove effective in destroying the insect itself at a minimum of cost, and without having any objectionable properties so far as the fully-matured fruit is concerned. Spraying with arsenates, and particularly arsenate of

Fig. 3.—When to Spray.
Left, too early; centre, the correct stage; and right, too late.

Fig. 4.—Types of Spray Deposit.

A—Apple sprayed with lead arsenate alone. B—Apple sprayed with lead arsenate to which casein spreader has been added.

lead, has been the standard method of dealing with the codling moth since sprays were introduced about the beginning of the present century. To a certain extent, this method has provided a quite efficient control, but it suffers from the objection that there is a considerable arsenical residue present on the fruit at picking time (see Fig. 4). This is a serious matter, as Great Britain has imposed an embargo on the importation of apples and pears containing more than 0.01 grains of arsenic per pound of fruit, the arsenic being reckoned as arsenic in arsenic trioxide. In the departmental tests at Harcourt the aim has been to obtain a spray programme which, in addition to giving a more efficient control of the codling moth than arsenate of lead alone, would be economically sound and leave an arsenical residue below the limit prescribed by law. The principal material used in the tests at Harcourt has been a white oil emulsion, and the results with this have been very striking. The results of the experiments at Harcourt, over the period of three years in which the white oil has been used, are set out in Table I below.

Spray Programme 1, shown in this table, consisted of five sprays of arsenate of lead paste (5 lb. in 80 gallons of water). The first spray was applied when about 80 per cent. of the petals had fallen from the flowers, and the second ten days later. The remaining three sprays were applied at intervals of approximately four weeks. Spray Programme 2 consisted of two calyx sprays of arsenate of lead paste (5 lb. to 80 gallons of water), followed by three sprays of white oil emulsion applied, at a strength of 1 in 60, at intervals of approximately four weeks. Spray Programme 3 consisted of two calyx sprays of arsenate of lead paste (5 lb. to 80 gallons of water), followed by a white oil spray (1 in 60)

Spray Programme.	Percentage Codling Moth at Picking Time.			Arsenical Residue in Grains per lb. of Fruit.		
	1929–30.	1930–31.	1932–33.	1929–30.	1930–31.	1932–33.
1. Arsenate of lead alone	17·6	16·7	7·3	*	0·032	0·039
2. Arsenate of lead calyx sprays followed by white oil sprays	3·6	6·2	4·2	*	0·0022	0·006
3. Arsenate of lead and white oil sprays alternately ..	3·8	11·3	4·2	*	0·015	0·008

* No analyses made.

one month later; then an arsenate of lead spray one month later, and finally another white oil spray (1 in 60) a month later again.

The results show that the percentage of codling moth was considerably reduced with the oil spray, while the residual arsenic was definitely reduced below the limit prescribed by law. It can be shown also that, when the costs of the above spray materials are considered, both of the oil spray programmes are economically sound, i.e., that the extra cost of the oil in the programme is more than balanced by the increased yield of marketable fruit. These tests indicate that fruit-growers should include spraying with white oil in their codling moth spray programmes. Either of the spray programmes 2 or 3 can be recommended.

(*c*) *Bandaging.*—Bandaging the trees by placing around the trunks some material which will act as a trap for the larvae seeking a place to pupate is an important aid in the control of the codling moth. Bandages may consist of two types—

(i) Hessian bandages.

(ii) Chemically treated bandages.

Hessian bandages are made of a material which is fairly thick and close in texture, wheat-sacks or wool-bales being ideal for the purpose. They should be cut into strips about 6 to 8 inches in width, folded once, with the opening of the fold facing downwards, and attached to the tree so as to be clear of the ground (see Figure 5). One method of attaching the bandage is to drive into the trunk a fine nail, allowing it to project about three-quarters of an inch. One end of the bandage is hooked on to the nail, the bandage being carried around the tree, and the other end hooked over the same nail. One end should overlap the other by 2 or 3 inches. The bandages should be put on the trees about mid-November, and removed not earlier than the beginning of June nor later than the end of August. In bandaging with hessian the following points are important:—

(i) The trees should be thoroughly scraped free from all rough bark before the bandage is applied; otherwise half the efficacy of the band is lost;

Fig. 5.—Hessian Bandage fixed with a Single Nail.

(ii) the material used must be of a fairly thick and close texture; and

(iii) bands must be examined every ten to fourteen days; otherwise they form ideal breeding-grounds for codlings.

Unless this condition is complied with, it is much better to have no bandages at all.

The object of the chemically-treated bandage is similar to that of the hessian bandage, with the addition that it is designed to destroy all grubs that enter the bandages (see Figure 6). thus obviating the necessity for regular examination. Chemically-treated bandages have been tried out by the Department during the past year, when extremely successful results were obtained. These bandages may be purchased ready for use or prepared by the orchardist himself. The chemical material used is known as beta-naphthol, and this is dissolved in engine oil at the rate of 1 lb. of beta-naphthol to 1½ pints of engine oil. The

Fig 6.—Portion of a chemically treated band showing captured larvae.

oil and the naphthol should be mixed together and heated up to 270° F. As the naphthol boils at between 280° and 286° F., and boiling is unwise, some care must be exercised. Bands of corrugated cardboard, 2 or 3 inches wide, are dipped into this hot solution for a few seconds only. These bands are allowed to dry, and are tacked on to the tree with the corrugated side next to the bark. They are left on the tree for the whole season. Gloves should be used when dipping the bandages, as the material is rather irritating to the skin.

(*d*) *Lures.*—Lures consist for the main part of glass or porcelain jars of about 1 pint capacity, containing either fermented apple juice or a 10 per cent. vinegar solution. These jars are hung in the tree, with the object of trapping the adult moths. Best results are obtained when these lures are hung in the upper third of the tree. The lures serve a double purpose—(1) they trap a large number of moths actually flying in the orchard (about 60 per cent. of the many thousands of moths trapped in the course of our experiment were females in a fit condition for egg-laying); and (2) they serve as a most useful guide for the determination of the correct time at which to apply the sprays. Occasionally growers apply some of their sprays at the wrong time, and the spray is partly wasted. By using lures, and by determining, by counting, the actual number of moths caught, they are able to tell when the particular brood concerned is reaching its maximum.

Regulations.

Regulations under the Orchard Supervision Act require that—

(*a*) The owner or occupier of any land on which are any trees, plants, or vegetables infected with or likely to be infected with insects, fungi, or diseases shall take all such measures and do all such acts as are prescribed by these regulations or such other measures or acts as an inspector orders to be taken for the effectual treatment of diseased trees, plants, or vegetables and the effectual eradication of disease and the destruction of any insect or fungus.

(*b*) *Codling Moth.*—All apple and pear trees shall be sprayed with arsenate of lead or an approved insecticide to the satisfaction of an inspector. The strength of the spraying mixture shall be not less than 1 lb. of arsenate of lead paste or its equivalent to 20 gallons of water. In addition to spraying as aforesaid, all infested apples and pears and other infested fruits shall be collected by the owner or occupier of any land and destroyed at least once in each period of four days. All apple and pear trees shall be kept clean of dead loose bark and broken limbs. Any stakes, props, or other materials likely, in the opinion of an inspector, to harbour the larvae or pupae of the codling moth shall be removed and, if found to be infested, shall be destroyed.

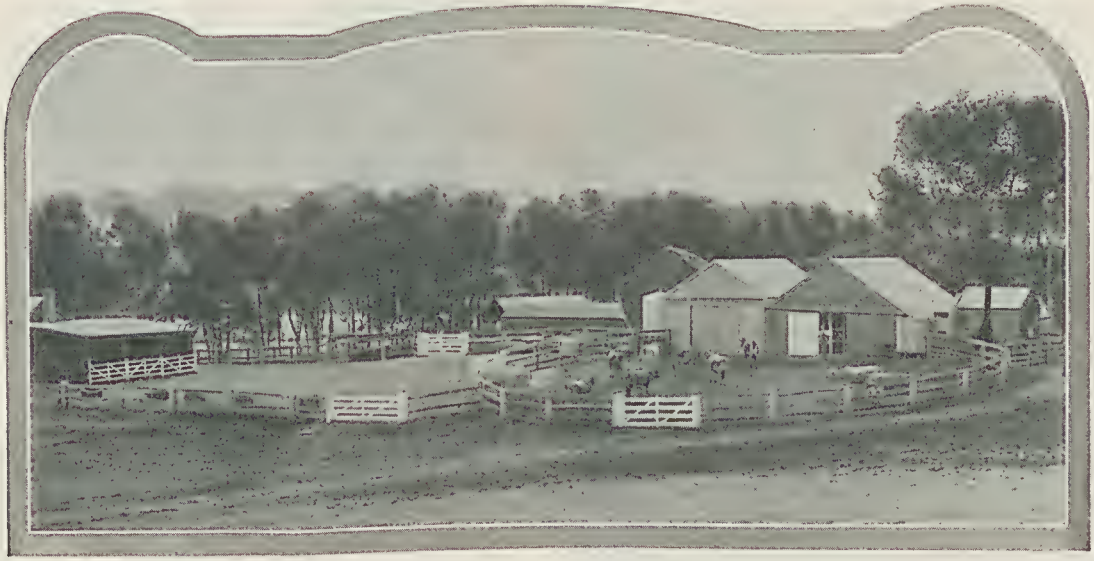
General Recommendations.

1. Incorporate in your spray programmes two or three sprayings with a recognized white oil emulsion, 1 in 60, after the initial early sprayings with arsenate of lead. These can be used solely or in alternation with arsenate of lead. It will be found that the percentage of codling moth is considerably reduced, and at the same time the arsenical residue will be reduced below the limit allowed by law.

2. Pay strict attention to orchard hygiene in the matter of clean packing-sheds, clean poles, props, and cases.

3. Bandage the trees either with closely-woven hessian bandages, or with chemically-treated bandages. If hessian is used, examine these every ten to fourteen days, and destroy the grubs found.

4. Use lures in the trees as an aid to determining the correct time at which to apply sprays.



Dairy Equipment

By J. M. Kerr, Chief Dairy Supervisor

FROM the hygienic point of view, as well as the economic, the very best equipment a dairy farm can possess is an owner who has, firstly, a high appreciation of his moral obligation to keep machinery and utensils clean, and, secondly, a good understanding of how to do so.

Mere buildings, machines, and utensils, however elaborate or costly, will not compensate for lowness of aim on the part of their owner, and no mechanical appliance can ever be a substitute for human zeal and human expertness.

There is no dairyman, no matter how excellent, whose work would not be still better if it were made easier, and there is certainly no structural or mechanical addition imposed by law that does not represent a saving of time to any one bent on producing the best of which he is capable. Of course, to the man who has no standard of hygienic quality at all, but simply accepts what comes from the least possible labour, even such a well recognized improvement as, say, a cream-cooler, is likely to be a time waster rather than a time saver.

When a cow-shed floor is rough and uneven, as well as dirty, it is reasonable to believe that it might not be quite so dirty if it were so designed that it could be easily cleaned.

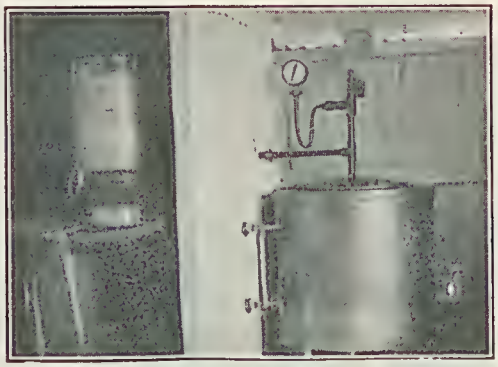
Where the delinquency is but slight, some improvement of appliance may serve to better the product, but with one who keeps nothing clean, time or no time, facility or no facility, every extra appliance is but an extra menace; for there is none that does not need regular cleaning. It is rather wonderful what good quality of milk or other dairy produce can be turned out of even ill-equipped premises if only the owner has that native sense of responsibility which is of more consequence than all the structural or mechanical adjuncts ever made.

There are, however, certain sanitary defects with which a good quality product is never associated; one of these is unclean utensils and another is dirty milking. No good dairyman, however humble his farm, will be found dispensing with any apparatus necessary for effective cleansing of utensils, of the cow's udders, and of the milker's hands and fingernails, for dirt in any of these situations makes clean milk an utter impossibility.

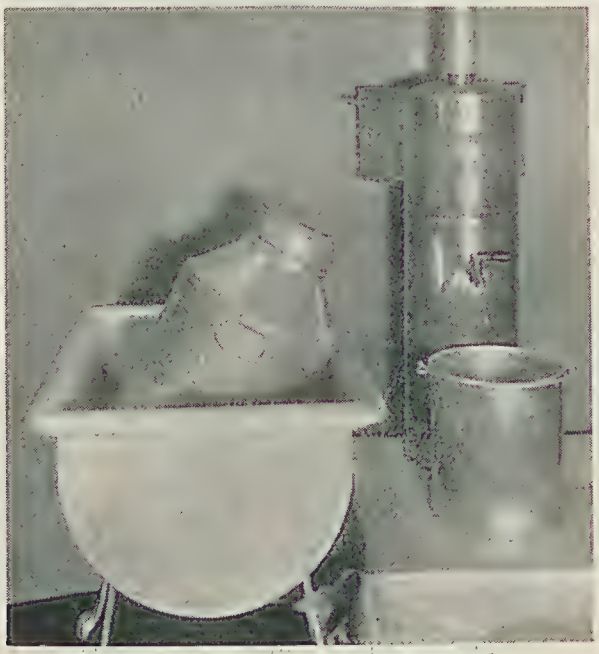
One of the first essentials for the production of good cream is a suitable milking-shed.

Apart from convenience and comfort, a shed is necessary to protect milk from dust, which is no small menace in such a climate as ours. Because bail-milking—the only really convenient way—involves animals being on the same floor over a considerable period of time, provision must be made for a floor surface that is not too difficult to keep clean. Here it is that the strong, smooth, and impervious floor, always associated with a good milking-shed, serves if the guttering is also strong and impervious, and in the right position close up behind the cow. No cow-shed is complete without a shovel and a good bass broom. These should certainly be part of the equipment of every milking-shed. There are people (and dairy farmers among them), who profess to regard the provision of a milking-shed as unnecessary, and actually less sanitary than open-air milking. This claim could be substantiated only if rain and dust storms never occurred during milking hours.

Open-air milking can hardly be otherwise than filthy in wet weather, and makes adequate washing of hands and udders quite impracticable. Every modern milking-shed must have provision for the washing of udders. Too often it is insufficient even in fair weather conditions, but on rainy days, when udders are liable to become muddy, it is ridiculously inadequate. The work should be done with warm water, or at least water with the chill off. It also needs a full-sized cloth frequently wrung out, not back into the vessel containing the wash-water, but into the gutter. The final use of the cloth on each udder should be as a drying towel after it has been wrung dry, for notwithstanding the need for much water, there should be no drippings. When the milking of the herd is finished, the wash-cloths must be given a thorough rinsing, and then heated through and through with boiling water; they should then be hung up in whatever sunlight there is to dry. No cloth at all is better than a dirty one. Care is required for the washing of a cow's udder properly, just as care is essential for the hygienic milking of a cow, and the pity is that, notwithstanding their importance to the nation's health and solvency, so little recognition is given to their successful accomplishment.



A Sterilizing Plant.



Two cleaning units—a water heater and an ample-size wash-trough.

Equipment for the regular washing of hands before each cow is milked should be entirely separate from that used for washing the udders. The only really effective hand-washing appliance is a tap under which the hands can be washed without fouling in any degree the water to be used subsequently. At least one fresh clean towel for each milking is an essential part of the hand-washing equipment, but it is really impossible to keep a well-used towel clean enough throughout a whole milking unless running water is being used.

If milk is allowed to stand in the cow-shed before delivery to the dairy (a practice easily overdone), a bench on which to stand the containing vessels is necessary, as is also some form of protection from flies.

The first containing vessel the milk enters is, of course, the milking bucket; it should be entirely free from rust, and breaks and seams; therefore a petrol tin should never be used.

Other necessary utensils are a strainer, a vat, a separator (with capacity to spare), a cooler, cans, a metal-gauze cream-can cover, a metal cream-stirrer, and a wash-up plant, including troughs, brushes, water-heater, and hook. The strainer is best used in the receiving vessel in the cow-shed. Its only function is to take out any undissolved forms of foreign matter like hairs and bits of chaff, and, as used in the cow-shed, to keep out flies. It should always be recognized that soluble dirt, and the micro-organisms that accompany all dirt, are in nowise arrested by the strainer.

As a protective appliance, it is perhaps worth retaining if only to catch the occasional hair that *will* get into milk despite all care, but wire-gauze at best becomes sooner or later a likely source of contamination. It cannot be properly cleaned, and, unfortunately, the finer it is as a strainer, the harder it is to clean. The type of strainer which uses a renewable cotton-wool wad as the straining medium is the best, as the only metal perforations in this strainer are relatively large ones, and, consequently, are fairly easy to clean.

Efficiency and sanitation in the use of the cream separator entail that all the parts coming into contact with milk or cream must be washed and well scalded after every working of the machine, which in ordinary dairy practice is twice daily. Rust is very apt to occur in the separator discs because of their tendency to lie close together, and thus hold water. Because rust is damaging to milk, it must always be guarded against, and the best protection is the speedy removal of every trace of wash-water; this can be effectively done only by using really hot water as the final act of cleansing, so heating the metal that it dries itself on the rack, which is another one of the mechanical requirements.

Good practice demands a milk-cooler or a cream-cooler according as the sale is of milk or butter-fat. If milk or cream is made cool enough, it will keep indefinitely. The cooling should be done as soon as circumstances permit. Every dairyman needs cans as containers. They must be sound and free from rust throughout, and should be re-washed after their return from the dealer. Washing, of course, always implies a final scalding.

Cooling checks cream corruption.
[A cream cooler in position at the separator.

Occasional stirring is essential to the proper ripening of cream. The only safe stirrer is a metal one, non-absorbent, non-rusting, and effective by its design to move the lower layers of cream upward for thorough mixing. When cream is added from time to time the mass will never be of equal ripeness unless it is well stirred. Another reason for stirring is that a hard crust is liable to form on top of the cream, and so exclude the air, thus forming an excellent place for the rapid increase of harmful organisms.

The best dairy practice demands the use of a metal gauze cream-cover. Vermin, like mice and rats, and flies, must be excluded from the cream without keeping out the air, and nothing less strong than wire gauze can be trusted to do this. In order to keep the wiring as clean as possible, the cover should not be permitted to come into actual contact with the cream.

This brings us to an entirely indispensable provision which exists in widely different degrees on different premises. It is the washing-up plant, which should consist of at least two separate water containers in the form of troughs for cold and hot water, respectively; brushes, and a water-heating device in the shape of either a copper or steam boiler. Last, but not least, there should be a wire hook with which to lift the hot utensils out of the boiling water on to another necessary appliance—a rack—for thorough drying by both evaporation and draining. Unfortunately, the wire hook is the rarest of all dairy appliances—convincing evidence that the effective bubbling, boiling temperature is still being too often dispensed with. If one can handle utensils from the sterilizer with the bare hands, it is evidence that more heat is called for. Utensils simply *must* be too hot to handle, otherwise the job is being done in a slovenly way. The wash-up premises must provide reasonable comfort for the operator if the work is to be performed thoroughly. Such premises, along with a separator room and shed, and another building for cream storage, are necessary to a completely equipped dairy farm. The great essential in all these buildings is a clean atmosphere, which is possible only with a good non-absorbent floor, good drainage, dust-free walls, weather-proofness, and free circulation of air without admission of flies.

Three aids to dairy sanitation. A metal cream-stirrer; a metal-gauze cream-can cover; an effective wash-brush.

The cream storage on the farm must, of course, be designed for coolness, and in as sweet and dustless an environment as possible, protected from access of animals. The stand at the road gate where the cream awaits the factory wagon should always be elevated a few feet from the ground, and should protect the cream from the sunshine.

Few dairy farmers need telling that such appliances as cow-sheds, dairies, buckets, and separators are necessary, but there is yet needed on many farms a greater appreciation of the finer points, such as udder-washing, hand-washing, cream-cooling, cream-storing, and cream-protecting, and yet more frequently the well-used wire hook which indicates the use of the indispensable boiling water.

Grass Thrips Attacking Tobacco Plants

(*Anaphothrips obscurus* Müll)

By G. E. Coghlan, Tobacco Expert, and R. T. M. Pescott, M.Agr.Sc., Entomologist

IT is a well-known fact that a species of thrips is responsible in certain seasons for considerable damage to the flowers of most varieties of fruits. It is not so well known, however, that another species is responsible, in certain seasons, for severe damage to tobacco plants, both to the seedlings while still in the seed-beds, and to the growing plants in the field. The thrips concerned is an introduced species *Anaphothrips obscurus* Müll, which was recorded on tobacco in New South Wales by Froggatt (1920), and also on grasses in America by Hinds (1899), where it was known as the Grass Thrips.

Field observations have disclosed the presence of thrips in the tobacco crop in Victoria for several years past, but it was not until the present season, 1933-34, that this insect assumed any economic importance through damage done to the leaf. In past seasons, thrips have appeared annually on the seedlings in the seed-beds, and caused a certain amount of weakening of the young plants. Also, in the field, several instances have been noted of thrips in large numbers on the tobacco plants, but they have usually been confined to the lower and trashy leaves, and very little actual damage has resulted.

Fig. 1.—Tobacco leaf from Pomonal showing early stage of attack by Thrips. Note the "silver-frosted" areas.

Fig. 2.—Tobacco leaf from Pomonal showing later stage of attack by Thrips. Note dead portion of leaf at butt end.

A report received from the Pomonal district early in April, 1934, drew the writers' attention to some serious trouble in the tobacco crops there. An examination of infected

plants disclosed the presence of thrips (*Anaphothrips obscurus* Müll) in large numbers on the under surfaces of the leaves. The typical symptoms of infested leaves can be seen in Figures 1 and 2. In the early stages of the attack, the most obvious symptoms noticed were a slight wilting, together with the appearance along the mid-rib and some of the side veins of small "silvery frosted" areas. Such areas are the result of the activities of the thrips feeding by means of their sucking mouthparts, and extracting the sap from these parts. In the more advanced stages of attack, the leaves showed a definite general "frosting" over the entire leaf surface (Fig. 1), and in the most severe cases of all, the leaves were so heavily infested that they were killed from the butt to half-way up the mid-rib (Fig. 2), and as a consequence had no market value whatever.

When harvested, those showing slight to medium signs of infection proved difficult to cure on account of the depletion of sap and moisture, the operator thus having little to work on during the "sweating" of the leaf. Any leaves attacked just prior to harvesting, when cured, showed a tendency to discolour and darken at the affected portions, the cause being probably a collapse of the cellular tissue, and the death of that portion of the leaf when heat was applied.

On the completion of the cure, the affected leaf may show the characteristic "silver frosted" appearance, or the discolouration previously mentioned, or even, in some instances, both of these defects. In either case, the appearances of the leaf are partly destroyed, and upon the severity of this injury depends the extent of the depreciation in value of the leaf when marketed.

The crops most severely affected were those which had not received any checks in their growth, were well developed, had been carefully tended, and were established in well tilled land. Seasonal conditions played an important part in their growth, as they were planted late in December, and received the benefit of rainfall above the average during that month and in January, 1934. Crops planted earlier in the season, that is, at the end of November, and early in December, received a check, and although they responded to the rain, were again affected by a dry period during February and March, 1934, which did not cause any set-back in the late planted, well-growing crop.

During March, no signs of the presence of thrips in the crops were seen in the Pomonal district, and it is therefore considered that the severe infestation in April was only of short duration prior to the investigation. However, in that period, considerable damage was done to standing crops, with a consequent monetary loss to the owners of those affected. It would appear that, while the dry conditions prevailed throughout February and March, the insects were not very active, but with the advent of rain early in April, and the ripening of the crop, they increased to sufficient numbers to cause extensive damage.

Observations of the activity of the pest in the Pomonal district did not show that it exhibits any preference for tobacco plants growing on a particular soil type, but, as previously mentioned, a definite preference for the well-grown crops was evident. This may, perhaps, be explained by the fact that such crops would have been carrying more sap, and would also have been more tender, whereas those which had received a check were inclined to harshness and stunting, with a consequent thickening of the leaves. It is well known that the well-grown crop always produces the best quality leaf. Further observations showed that where several varieties were growing side by side, and had received similar treatment in all respects, the thrips preferred those considered to be capable of producing the higher grade leaf, and which have better keeping qualities.

Description of the Thrips causing the Trouble.—Damage to growing tobacco leaves may take place as the result of the activities of either the larval or the adult thrips. As these two forms differ somewhat, a description of each is supplied together with Figures 3 and 4.

The larval thrips (Fig. 3) are creamish-white in colour. The head is small, antennae short and thickened, standing out in front of the head and composed of seven joints, of which the last four are closely joined together; eyes distinctly reddish. The legs are short, terminating in two claws. The body is spindle-shaped, tapering to the tip and terminating in a short, tubular process. The abdomen characteristically shows curious transverse striations produced by large numbers of minute hairs. The larvae as they approach the pupal state have darker coloured antennae, and the thorax and body are marked with yellowish tints. Total length ranges from one-fiftieth to one-twentieth of an inch.

The adult thrips (Fig. 4) has the eyes black or purplish-red; head yellow with the tip of the mouth dusky-brown. The antennae have the first segment light-coloured, and the others coloured with brown. The general colour of the thorax and abdomen is yellow with brownish bands across the abdominal segments; the wings are yellowish-brown with black feathery spines along the margin. The antennae are eight-jointed. The abdomen is elongate, broadly rounded at the sides, coming to a tubular point at the apex, and composed of nine segments. The total length is about one-twentieth of an inch.

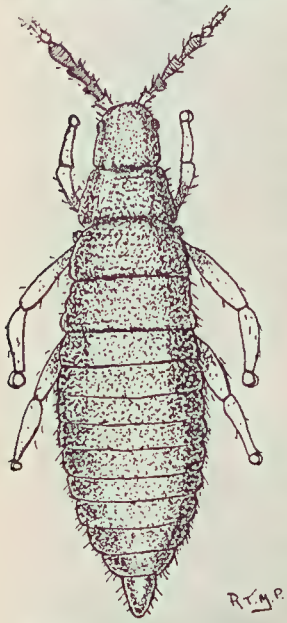


Fig. 3.—Grass Thrips—Larva.

Control Measures.

1. Under certain conditions, severe primary damage may occur on young seedlings in the seed-bed. Sprays of nicotine sulphate—1 oz. to 5 gallons of soapy water; or kerosene emulsion—1 lb. to 5 gallons of water—applied with particular reference to the under surfaces of the leaves, will prevent serious damage to the seedlings.

2. When growing crops are attacked, unless the crop is one of great promise, and the grower is prepared to spend a fair amount of money on spraying or dusting, very little can be accomplished. If a crop is attacked very late in the season, harvesting a little earlier than normally intended may save portions of it from serious damage.

3. The destruction of all waste plants and material in the paddocks, either by ploughing in or by burning, after the tobacco has been cut and removed will destroy all the wintering thrips and their eggs.

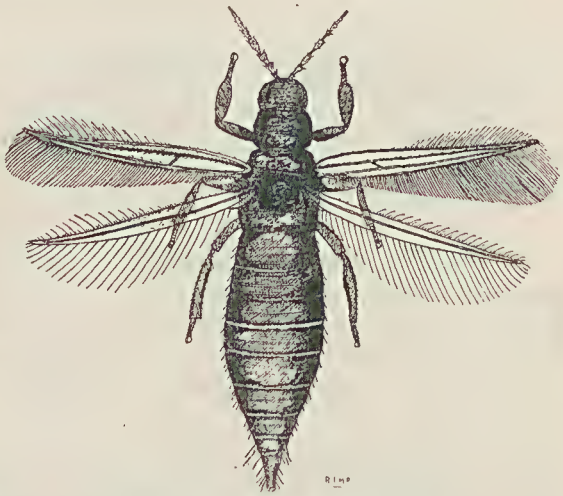


Fig. 4.—Grass Thrips—Adult.

Where the damage done is not of such extent as to prohibit the harvesting of some of the leaf, such leaf must be kept separate and marketed separately, so as to avoid any trouble arising through depreciating the value of otherwise sound quality leaf by mixing it with an inferior grade.

Orchard and Garden Notes

By Edward E. Pescott, F.L.S.

The Flower Garden.

FLOWERING shrubs may now be planted in the garden or in the avenue. Before planting, the whole of the area should be well dug over, and some old manure worked into the soil. Before taking the plants from the pots, they should receive a good soaking for ten minutes, so that they will transplant easily without root damage. If necessary the main roots should be straightened and the soil must be well pressed and firmed around the plant.

Not all garden shrubs should be pruned in the winter. The correct time for pruning is immediately after the flowering season. Many good floral displays are ruined, especially in the spring-flowering shrubs, by the cutting away of the flowering stems in winter.

Roses should now be pruned. The pruner must endeavour to produce a shapely bush, with the branches or limbs all evenly spaced, and an open centre. The open centre is for the purpose of allowing the sunlight to reach all sides of the bush.

As the rose flowers on the new wood, all weak and thin old wood should be pruned away. All shoots could be cut off right to the base at the stem. No short stubby pieces should be left on the leaders. After the bush has been well cleaned out, all leaders should be cut back to a strong outside bud.

For a show of flowers in spring, it is not yet too late to plant out Primula, Stocks, Wallflower, Pansy, Viola, Cineraria, and Iceland Poppy plants.

Erica hybrida.

The Vegetable Garden.

Now is the time to sow, under cover of course, tomato seed. The seed should be sown in boxes or pans in a light sandy, leaf-mouldy soil. As it germinates, the seedlings may be pricked off into pots or boxes, and hardened off before planting out. The frames or houses should not be too hot; otherwise the plants will become drawn and tender. Even at the expense of having a dwarf plant for setting out, it is desirable to have a sturdy hard one.

Beds should be deeply dug over, and enriched for a supply of lettuce, which loves a friable, rich soil.

Seed should be sown in rows, and when the seedlings are large enough for thinning, they should be thinned, and a plant left at every 6 or 8 inches. These plants will give the first crop. The thinned ones may be transplanted for subsequent crops.

Plots of broad beans and green peas should be prepared. The peas need not be soaked, but the bean seed should be soaked in a weak bluestone solution (1 oz. of bluestone to the quart) to kill any spores of bean rust. Both peas and beans are lime-lovers, and so lime should be used in the beds.

The Orchard.

The subject of orchard heating is becoming of more prominence each year in Victoria, and many experiments or tests, both private and commercial, are being carried out. When it is realized that in some parts of Victoria many acres of trees, citrus in particular, are checked each year, and in some cases rendered quite useless, the question of frost burn prevention is an urgent one.

One company has experimented with oil heaters, which are already in common use in America. But the cost of oil, which is lower in America than in Australia, may tend to restrict the use of this form of orchard-heating here.

Quite simple burners are constructed by using a small 2-gallon oil drum or nail can, and suspending a piece of rag for a wick into the oil. The number of heaters required is still a matter of debate, but in the tests carried out 50 per acre were used.

Some growers have tried briquettes; and it is claimed that the cost of such is very low, and therefore economical. By whatever medium the temperature of the orchard or grove is raised, it is imperative in frost areas; and the lack of natural fuel will force the use of oil, coal, or some similar heating medium.

The Director of Agriculture (Mr. H. A. Mullett, B.Agr.Sc.) making presentations to Messrs. C. French and D. B. Adam, B.Agr.Sc. Mr. French, after 51 years service, mainly as Entomologist and Biologist to the Department of Agriculture, has just retired. Mr. Adam, Plant Pathologist, has resigned to take up a position in the Waite Agricultural Research Institute at Adelaide.

Tuberculosis in Poultry

Preventive Methods Outlined

By R. N. Johnstone, B.V.Sc., Senior Veterinary Officer

TUBERCULOSIS is a chronic infectious disease affecting man and all domestic animals. The existence of the disease amongst fowls and other birds has been recognized in Europe during the past 50 years. Occasional outbreaks are met with in Victoria, and while there is at present no means of arriving at an accurate estimate of the annual loss caused, the possibility exists that, if the disease were more readily recognizable, a far greater number of outbreaks would be reported. Once tuberculosis makes its appearance in a flock, although a great number of birds may not die at one time, the general unthriftiness of the fowls, which renders them unfit for table use, and decreased egg production make the industry unprofitable and discouraging to the poultry-farmer.

The disease is due to the bacillus *Tuberculosis avium.* Although this organism differs slightly on cultures in artificial media, and in its effect on experimental animals, from that which causes tuberculosis in man or animals, it has the same staining characteristics; morphologically they are identical, and the avian type of bacillus has been isolated from many tuberculous pigs, and in several instances from human beings.

During recent years the occurrence, in the United States of America, of tuberculosis amongst pigs reared on farms on which all cattle were free from this disease caused grave concern, but careful investigation disclosed the fact that the infective organism was of the avian type, and that infection had been derived from tuberculous fowls on the farm. Pigs fed on the carcasses of fowls which have died of tuberculosis or on food that has been contaminated with the droppings of tuberculous poultry may become affected with the disease. The avian bacillus is very resistant to outside influences, such as heat, sunlight, and disinfectants.

Healthy fowls also may be infected by eating food which has been contaminated by the droppings of infected birds. When intestinal ulcers are present, such droppings contain enormous masses of bacilli. Infection may also be brought about by permitting fowls to have access to the carcasses of birds which have died from the disease. Further, the disease may be introduced with infected eggs, the whites of which contain virulent bacilli.

Symptoms.

Having gained entrance to the body in this manner, the organism chooses a favorable location in which to multiply, and lesions may be set up in the intestines, in the liver and spleen, in the lungs, or in the bones and joints. As the disease progresses, although the appetite may, for some time, remain unimpaired, the bird loses condition. On examination, it will be found that the flesh has almost entirely disappeared from the breast bone. Later on, the bird becomes anaemic, and paleness of the membranes of the mouth and of the wattles and comb will be more and more pronounced. At this stage the appetite is affected, the bird becomes listless, and may be easily captured. Finally acute yellow or greenish diarrhœa develops with resultant complete exhaustion and death. This stage of the disease is most dangerous to the remainder of the birds, for then the droppings contain large numbers of bacilli.

Tuberculosis of the bones and joints is very common. The knee and shoulder joints are most frequently affected. The joints swell, the ends of the bones become enlarged, and the animal shows lameness. This is frequently the only symptom noticed in the early stages, and mention of it in letters requesting advice leads one to suspect the presence of this disease.

Although some fowls affected with tuberculosis may die a few days after the first appearance of symptoms, as a general rule they linger for weeks, becoming gradually more anaemic and emaciated, until death finally ocurs from complete exhaustion. Some outbreaks follow a more rapid course than others, depending generally on the housing conditions, the general health and resistance of the birds, and the system of management adopted.

Diagnosis in the living fowl is particularly difficult. No symptom or group of symptoms can be considered characteristic of the disease. The tuberculin test is not applicable, because tuberculous fowls will not give specific reactions to tuberculin. Although symptoms may give rise to suspicion, the disease can be positively identified only by post-mortem examination.

Post-mortem Appearance.

Post-mortem examination shows that the liver and spleen are most frequently affected. Irregular nodules, varying in size from a pinhead to a pea, and sometimes larger, are found in the substances of these glands. The contents of these nodules are white or yellow in colour; sometimes they are easily broken down; occasionally they become calcified and feel gritty when cut. The lesions are distinct from the surrounding tissue, from which they may be separated easily; they are surrounded or enclosed by a capsule of connective tissue. In rare cases, lesions are seen as minute grey or yellow points, sometimes scattered singly through the substance of the gland, or gathered together in groups.

The diseased gland, especially in chronic cases, is considerably enlarged and friable. The liver may be twice its normal size and the spleen four times. The intestines may or may not be involved. When lesions are present the inner (digestive) surface will be covered with small yellowish nodules, and ulcers may be present. On the outer (serous) surface, nodules varying in size from a pea to a hazel nut will be firmly attached. Usually these nodules communicate with the inner surface of the bowel through a fistulous canal, and by this means large numbers of bacilli gain entrance to the bowel, and are distributed in the droppings. The interior of the small nodules is greyish-yellow in colour, and is tough; the larger ones may contain cheesy areas, or may consist wholly of a yellowish crumbly substance.

The lungs are sometimes affected, and contain nodules resembling those found in the liver. In the joints, which are commonly affected, the cavities are found filled with a cheesy mass; the ends of the bones show erosions, i.e., they are roughened. Cheesy areas may also be found in the shafts of the bones.

Fowl showing Tuberculosis of the Liver.
The small white spots on the liver are the lesions caused by the disease.

Prevention.

Medicinal treatment is of no value; therefore, preventive measures must be adopted. Because of the insidious nature of the disease and difficulties in diagnosis, isolation of all affected animals is not possible. The most practical and economical method of procedure is to slaughter the whole flock as soon as the disease is recognized. Chickens in good flesh may be used for food if, on examination, the liver or spleen shows no white or yellow spots (these usually are from the size of a pin point to that of a pea or larger), and provided there are no nodules or lumps on the intestines. When the disease is present the flesh cannot be considered suitable for food.

The poultry yard as well as the houses and coops should be thoroughly cleaned and disinfected before fresh stock is acquired. Disinfection is necessary because of the fact,

already shown, that the bacilli are found in the droppings in great numbers. For this reason every effort should be made to destroy the droppings.

To Disinfect Fowlhouses.

1. Remove all litter from floors, nesting places, and yards, and to avoid contamination of the surrounding soil, burn the rubbish as near the building as possible.

2. The contents of all hoppers, feed bins, and troughs, such as dry mash or other food or grit, should be burnt with the litter. Scald all utensils, pans, &c., using steam, if possible.

3. Remove all nests, movable roosts, windows, and portable fixtures from buildings; thoroughly wash with warm water and soap, to which disinfectant has been added, and place in the sunlight.

4. Thoroughly sweep down the inside of buildings so as to remove all dirt, cobwebs, &c., or, if possible, flush them out with a hose.

All accumulations of hard droppings should be softened with water and scraped off with a sharp instrument.

Having carried out the above instructions, disinfection may now be commenced. Thoroughly spray all buildings, fences, yards, and appliances with a 5 per cent. solution of lysol. Sunlight is the best of all disinfectants, and its free access to all buildings, &c., should be allowed where possible.

Slake some fresh quicklime by adding boiling water (when heat ceases the lime is slaked). Thin to the consistency of milk with boiling water, to which has been added 1 oz. of alum, 1 oz. of powdered glue previously dissolved in hot water, and 4 oz. of lysol for each gallon of completed wash, and strain through two thicknesses of cheese cloth. The easiest method of applying lime wash is by means of a spray pump, which can be purchased at a reasonable cost, and can be used for other purposes. In the absence of a spray pump, a whitewash brush may be used, although it is difficult to fill the cracks and crevices without a stream to drive in the solution. These cracks serve as breeding places for ticks, lice, &c., and should be given careful attention.

Where an infectious disease such as tuberculosis is present it is wise to spray the interior at least twice with an interval of one week between each application. The runs should be covered with quicklime, and the surface ploughed up or dug. They should be divided and changed each year, one-half being used for rape or other green crop. If portable houses are in use, they should be moved frequently, as feeding fowls on the same ground year after year serves to infect them with numerous diseases. Disinfect in the spring and autumn each year, if possible, and by all means before introducing fresh stock.

Warning to Peach Growers

DURING a recent inspection of peach orchards in the Goulburn Valley and Doncaster districts it was observed that the egg-laying forms of the Green Peach Aphid were abnormally numerous on peach trees, and that the winter eggs of the insect were being deposited on the trees in great numbers. This heavy deposition of eggs probably portends an epidemic outbreak of the insect next spring, and if weather conditions are cooler than usual during next September and October, such an outbreak will undoubtedly occur.

The abundance of the aphid is accounted for by the unusual prevalence during the past summer and autumn of various weeds on which the insect normally exists from December to April each year. These weeds have provided an ample food supply on which the aphids have been able to increase greatly in numbers before migrating to the peach trees.

It is recommended that peach and nectarine trees should be sprayed with tar distillate winter wash at a strength of 1 in 35 before 15th July, in order to prevent outbreaks in individual orchards. Where trees have been pruned before being sprayed, the prunings should be burned to destroy aphid eggs on them.

Further spraying experiments against the Green Peach Aphid are being carried out this year at Mr. W. Young's orchard, Ardmona. The object of this work is to confirm previous results, and to demonstrate that the aphid can be effectively controlled by means of suitable egg-killing winter washes.

KEIGHLEY M. WARD.

Professional Paper

[This section is devoted to professional papers and articles of a scientific character.]

Investigations on Flag Smut of Wheat caused by Urocystis tritici Koern.

By W. B. Miller, M.Agr.Sc., Inspector of Agriculture and C. R. Millikan, B.Agr.Sc., Science Field Officer

Introduction.

FLAG Smut is a serious disease affecting wheat crops throughout Australia, and in other parts of the world. Unfortunately, simple means for its eradication have not been discovered, though control by various methods has been partially successful. The Department of Agriculture, Victoria, during the past three years has conducted experiments to determine the reaction of varieties to the disease, and has studied various other aspects related to the problem of its control. The principal results of this work are given in the following paper:—

Distribution and Economic Importance.

Flag Smut of wheat was first officially recorded by the South Australian Commission on Cereal Diseases in 1868(53). "Black Rust" as it was then called, was described as a familiar disease to farmers, who were recommended to adopt certain cultural practices to protect their crops. Since then, the disease has been recorded in all the main wheat-growing areas of Australia, and in many other countries. It is estimated by Carne(10) that Australia loses on the average 3 per cent. of its grain yield each year as a result of Flag Smut.

In Victoria the disease was first reported in 1892(38), and since that date has become one of the most serious of all wheat diseases in this State. It is seldom that a crop is wholly free from Flag Smut, the losses ranging from a trace up to 80 per cent. Serious attacks appear to be most frequent in the Northern(39) and Mallee districts, particularly when dry weather retards the growth of the plant. The serious nature of the disease in Victoria has been aggravated in the past by the widespread use of susceptible varieties such as Federation and Free Gallipoli, the use of such varieties being due to their prolificacy under general conditions. In 1931 the two varieties mentioned were sown on 46 per cent. of the total wheat acreage in this State.

The first reference to Flag Smut in New South Wales was made in 1891 by Cobb(14), who remarked that "It is not rare for half the crop to be lost through its ravages, and a loss of 10 per cent. is common." Recent reports show that the disease is still serious there. Arthur(1) states that "Flag Smut was the worst enemy of the wheat crop in the Narromine district" in 1926, while an annual loss of 2,000,000 bushels, or over 4 per cent. of the yield, was estimated by Noble(45) to be caused to the State by this disease. The New South Wales Biologist(6) reports that losses up to 90 per cent. of the wheat crop were caused by Flag Smut in certain north-western districts where continuous cropping is practised. Stenning(61), however, makes the following observation: "Speaking generally, Flag Smut is on the wane, evidently as a result of the intensive cultivation of the resistant variety Nabawa."

Flag Smut is somewhat widely distributed in Queensland. In 1928, Simmonds(60) records that in most cases the infection* was slight, but in some crops it reached 20 per cent. The disease was first recorded in that State in 1906(38).

In Western Australia, Carne(10) has traced the occurrence of the disease back to 1921. He adds: "It is possible, of course, that the disease occurred earlier and was overlooked."

* "Infection" is generally used to denote the penetration and establishment of the fungus within the plant, but, in addition, the word is used, as in this paper, to describe the subsequent development of the parasite in relation to the host.

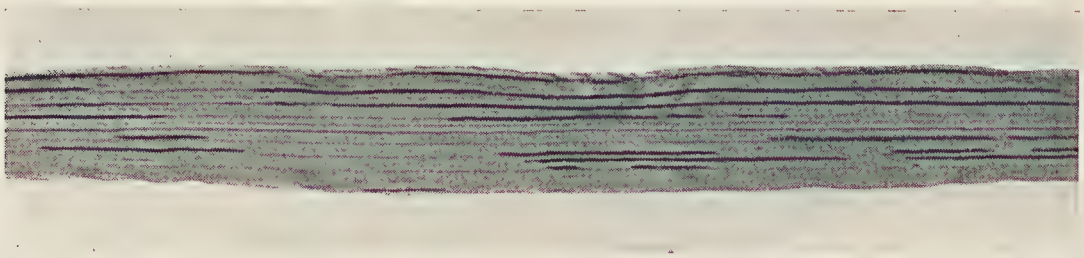


Fig. 1—An infected leaf showing the typical appearance of the sori in the early stages of the disease.

The small number of serious losses caused by Flag Smut reported from Western Australia is attributed by Limbourn(36) to the widespread use of Nabawa. Thomas(67), however, states that "this disease is becoming more in evidence each year, due to the fact that considerable numbers of farmers fail to recognize the disease when present in the crop."

The disease was first recorded in the United States of America in 1918-19(28, 66), its origin being obscure, as Tisdale states that the disease "could not have been imported from Australia in wheat exported to the United States of America from Australia." Flag Smut is now to be found in a limited territory in the States of Illinois, Missouri, and Kansas, but the losses in yield are not great.

Flag Smut occurs in a number of districts in the Western Province and Transvaal, South Africa(51, 68). It is thought to have been probably introduced during 1915-16 in wheat imported from Australia for milling purposes. The disease causes heavy losses—up to 50 per cent. of the crop at times.

In China, wheat diseases cause an estimated loss of approximately 20 per cent.(48, 49). Flag Smut seems to be almost as prevalent as Loose Smut (*Ustilago tritici* (Pers.) Jens.), causing losses ranging from a trace to 20 per cent. Miyake(39) states that the disease was "very common around Peking."

Flag Smut has been known since 1895 in Japan(27), and between 1897 and 1902 the fungus was observed in various parts of Italy(2). The disease has also been recorded from Zaragossa, Spain(24); Cyprus, and Transcaucasia in South Russia(30); and India(63), where the disease was first recorded in 1905 from Lyallpur.

From the foregoing, it is seen that Flag Smut occurs in a number of countries, constituting in some a disease of major importance, but in others not being regarded as serious. Unlike rust, this disease seldom assumes epidemic proportions, but takes a steady annual toll of the wheat crop. From year to year, the proportion of the total wheat acreage which is sown with varieties of wheat susceptible to the disease, governs to a large degree the loss in yield which results from the ravages of Flag Smut.

Symptoms of the Disease.

As its name suggests, the typical symptoms of the disease are most frequently manifested on the leaves of an infected plant in the form

Fig. 2.—Infected plant of Federation. The tiller on the left shows secondary infection, with the production of an ill-developed head.

Fig. 3.—Infected and healthy plants of Joffre. Infected plant on the left shows the characteristic development of numerous spindly tillers. Note the twisting of the leaves.

of long streaks running parallel to the length of the lamina (Fig. 1). When first produced, these streaks, or sori, are white or greyish in colour, but later take on a dull leaden appearance, and the epidermis finally ruptures, liberating the black spores. It is for this reason that the disease is often termed "Black Rust" by farmers. In damp or misty weather the sori may remain covered for a long time.

These symptoms are constant in type, but vary in their occurrence and distribution on the plant. In addition to the leaves, sori are often developed on the leaf-sheaths, stems, and glumes. The first appearance of sori is governed to a large extent by the variety, and the conditions under which the plant grows. They may appear in the fourth or fifth leaf stage in plants grown in a glass-house, but under field conditions the first appearance is usually much later, being generally at least eight weeks after germination. In general, the more susceptible varieties exhibit sori at an earlier stage of growth than varieties which are comparatively resistant to the disease. In "resistant" varieties, the presence of the fungus in the host is often detected by the production of small smutted shoots arising from the base of the plant.

Two types of infection are noticed—"primary" and "secondary"—the difference being in the dates of appearance of sori. An example of secondary infection is shown in Fig. 2.

Before the appearance of the typical symptoms described above, it is often possible to distinguish between an infected and healthy plant. The infected plant generally produces a large number of thin-stunted leaves (Fig. 3) in which the symptoms described above later become manifest.

In other cases (Fig. 4) the plant becomes very thin and spindly, the infected leaves becoming very long in comparison to their width. These leaves feel limp like a wilting plant, and develop a yellowish green colour. This latter symptom is often difficult to notice in any individual plant, but when comparing large numbers of infected and non-infected plants in the field, the difference is apparent, becoming more marked after the appearance of the disease.

In the later stages of the disease, the leaves become twisted and curled, and the entire plant may be stunted and often totally destroyed before it comes into ear (Fig. 5). This is especially typical of "primary" infection. The ear is rarely formed, or if present is ill-developed (Fig. 2), containing small and shrivelled grain. It is rare for a smutted tiller to produce apparently healthy grain. Serious reductions in yield are experienced, therefore, in crops which are badly infected with Flag Smut. The loss in yield is dependant to some extent upon the severity of the symptoms manifested. In "partially" infected plants one to several apparently healthy tillers are produced, and these later

Fig. 4.—Infected and healthy plants of Free Gallipoli. Infected plant on the left shows characteristic spindly growth.

Fig. 5.—Infected and healthy plants of Federation. Infected plant on the left was stunted and completely destroyed.

develop grain. Some return is therefore obtained from plants showing this type of infection.

The Causal Organism.

(a) Relation to Stem Smut of Rye.

In 1873, Wolff(70) suspected the fungus causing Flag Smut of wheat to be *Urocystis occulta* Rabh., the same as Stem Smut of Rye. The causal organisms of these two diseases were afterwards shown, however, to be biologically distinct species, when Körnicke(34) in 1877 named the form of wheat *Urocystis tritici* Koern, basing his determination on morphological characters alone. He considered that *Urocystis occulta* is distinguished from *Urocystis tritici* by the more compressed, punctulate spores, which are not generally completely invested by the sterile cells, these latter being more compressed and flattened.

(b) Specificity.

McAlpine(38) conducted a series of infection experiments from which he concluded that the organisms causing Flag Smut of wheat and rye (*Secale cereale* L.) were not mutually infective. The same species could not therefore cause the two diseases. More recently Noble(44) has observed that the infection hyphae of *Urocystis tritici* are capable of entering rye seedlings, which are known to be immune from the disease, but no further growth results. No variety of *Triticum vulgare* Vill. immune to the disease is known. Infection experiments at the State Research Farm, Werribee, have shown that durum, monococcum, and polonicum wheats are very highly resistant(74). To date, attempts to extend the host range to other cereals and grasses have failed.

(c) Description.

The fungus belongs to the family *Tilletiaceae*. In *Urocystis* the spores unite to form permanent balls, consisting of an envelope of sterile cells surrounding one to several fertile spores (Fig. 6). The spores of *Urocystis tritici* are commonly two in a ball, although three or four are also met with. Each one of these inner fertile cells is capable of germinating and infecting the host plant.

McAlpine gives the following description of the fungus:—"Spore balls globose, ellipsoid, or oblong, bright golden brown, variable in size and shape, 16 to 40μ diam. or 24 to 40 x 24 to 32μ. Average 32 to 24μ. Spores spherical or oval, 1 to 4 in ball, occasionally 5, 2 to 3 common, 9 to 12μ diam, or 12 to 16μ long, sterile peripheral cells generally completely investing spores, or may be only partial, very pale yellow, ellipsoid to globose and bulging, 9 to 12μ long. The spore germinates in water, sometimes in 24 hours, and sometimes taking a fortnight, according to the age of the spore and the season of the year. It produces a promycelium which may either be unicellular or two to three celled. At the apex the conidia are formed, varying from two to six, but generally three to four. They are at first upright and crowded together, but gradually diverge, so that they stand out like finger-like processes. They are normally cylindrical, rounded at the free end, and unicellular, but many develop one or two septa. They vary in size, but are generally 12 to 15μ long, and 3μ broad. Sooner or later the sporidia, while still attached, begin to germinate at their free end by putting forth a slender germ tube, only about half the breadth of the sporidium, and this grows out to a varying length according to the supply of

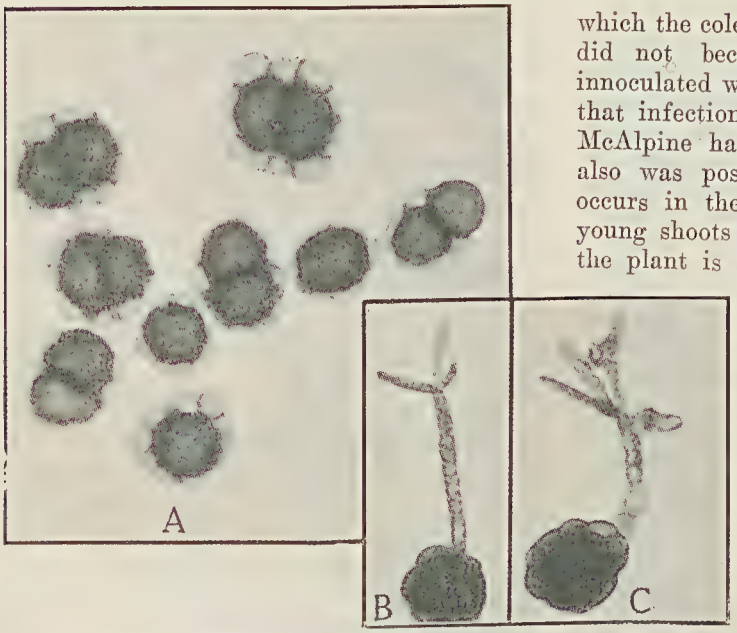


Fig. 6.—Spores of U. tritici, showing (A) the typical spore balls and (B and C) mode of germination. (After McAlpine x 500.)

nutriment. It is filled with dense protoplasmic contents, more particularly towards the tip. These slender, delicate threads, when they grow out to any considerable length, show an irregular curving, and represent the infection threads, which penetrate the young seedling, if they reach it at the proper stage of growth."

Life History of Urocystis tritici Koern.

(a) Stage at which Infection Occurs.

It has been accepted that *Urocystis tritici* cannot adopt saprophytic habits, as attempts to date to grow it on artificial media have failed, although Verwoerd(68) grew *Urocystis cepulae* luxuriantly. In consequence, investigations of the latter stages of the life history of the organism after the sporidial (or conidial) stage, must be carried out through the medium of the host plant.

The susceptible period for infection of the host plant is between the time at which the coleoptile penetrates the epidermis, up to the time this white sheath has been broken by the first true leaf. According to Verwoerd, the optimum period is apparently from the time the coleoptile appears until it reaches 1 cm. in length, and three or four roots develop. This probably varies with different varieties, as Noble(44) found that wheat seedlings in which the coleoptile was more than 4 mm. long, did not become infected when they were innoculated with dry spores. Verwoerd claims that infection by the root was possible, while McAlpine has declared that shoot infection also was possible. He states: "Infection occurs in the seedling stage, also when the young shoots are being formed, but not when the plant is above the ground."

Hecke(26) claims to have produced infection of the young shoots of Melandryum by cutting back two-year-old plants, and dusting the crown with spores of *Ustilago violacea* (Pers.) Fuckel. Subsequent shoots were infected. This method of infection has been termed "Triebinfektion," and Hecke suggests that it occurs with other fungi. Attempts of most experimenters to produce Flag Smut by this method have been unsuccessful, although Noble(43) obtained slight infection. It is probable that the most common method of infection of secondary shoots is by mycelium already present in the host plant, and that Triebinfektion occurs less frequently. Raw, at the State Research Farm, Werribee, has obtained infection by means of hypodermic inoculation of eight weeks' old plants. Unlike loose smut (*Ustilago tritici*), flower infection is unknown.

(b) Distribution of the Mycelium in the Host.

Jarrett(30) has noted that under conditions favorable to infection, the coleoptiles of "resistant" varieties are invariably penetrated by the fungus, which subsequently invades the tissues below the primary node. In the early stages of penetration the hyphae is intracellular, later becoming intercellular. An important difference between "resistant" and "susceptible" varieties lies in the subsequent development of the mycelium. In the case of "susceptible" varieties, the growth rate of the fungus corresponds with the meristematic tissue of the host, while in more resistant hosts the growth of the pathogen is inhibited, and its mycelium may not develop sufficiently to produce external symptoms. In such cases, a microscopic examination may reveal the presence of the fungus in the base of the tillers.

The mycelium in the internodes is mainly unbranched hyphae, while it is very branched in the nodes. In some wheat varieties the fungus grows right into the glumes and awns.

In badly infested plants the mycelium occurs in the vascular bundle, so that the plants are liable to wilt. It is for this reason that the disease has been described by Raw(52) as the "Tuberculosis of the wheat plant, since it strikes at the very lungs of the plant, manifesting itself in the leaf, sheath, and stem, completely destroying the tissues, and resulting in most cases in early death."

The characteristic parallel, leaden coloured lines, or sori, which appear along the length of the leaves, are often the first external symptom of infection. The first indication of spore formation is the accumulation of hyphae (or a sorus) in the intercellular spaces, in the tissue between the epidermis and vascular bundles, which force the cells apart. The spore forming hyphae branch at their free ends, and the first beginning of a cluster is indicated by the branches becoming swollen and curved, and winding themselves round each other generally in a spiral manner, so as to form a glomerulus or ball(38). The spores are formed entirely from these gelatinized central balls, and consist of a group of cells bound firmly together. At an early stage the spores are surrounded by slender curved branches from the hyphae which persist and form the envelope of the mature cluster of spores. When the spores are mature the epidermis ruptures exposing the black spore mass.

The sori may originate at any stage of the development of the wheat plant, but observations show that, in general, the more resistant varieties tend to exhibit sori at a later stage of growth of the host, as compared with susceptible wheats. It seems that the fungus forms its spores most readily in the younger tissues.

(c) Dissemination of the Disease.

The infected parts of the plants, breaking up and falling to the ground, constitute the main source of infection from year to year, the effect becoming cumulative if continuous cropping of an infected area is practised. Observations in Victoria show that Flag Smut is more prevalent on land which has grown wheat frequently than on occasionally cropped land, and that crops grown on new land, or on land left out to grass for a long period of years, are practically free from the disease.

Various workers (6, 8, 68, 73) have been able to germinate spores kept in the laboratory after periods ranging from five to nine years. The writers have obtained severe infection after three years. All spores do not necessarily germinate on account of the soil moisture present, but may retain their infective capacity for at least four years, so that an area which has produced a smutted crop remains a potential source of infection for a long period afterwards.

McAlpine(38) suggests age of spores as a factor influencing germination. It has been found that fresh spores will not germinate readily, a maturation period of approximately one month being necessary. Noble(44) has been able to shorten this maturation period considerably by drying fresh spores for 48 hours over concentrated sulphuric acid, after which he was able to germinate them. He found, in addition, that small amounts of certain volatile substances, such as benzaldehyde, salicyaldehyde, butyric acid, and acetone greatly stimulate the germination of pre-soaked spores.

Seed-borne infection is common, as the spores adhere readily to the wheat grain, particularly in the crease and the brush. Farm animals and machinery are potential sources of infection. McAlpine has recorded that horses and cattle fed on diseased hay have passed the spores of *Urocystis tritici* uninjured and capable of germination. Clayton(13) attributes the alarming rate at which Flag Smut has been spreading of recent years in New South Wales to the habit among local farmers of feeding horses on wheaten chaff infected with the disease. Putterill(51) states that the spores may be blown about by wind, carried on the hoofs of animals, or transported by irrigation water.

In Victoria wind is probably the chief agency by which the spores of the fungus are spread. This is suggested by the rapidity with which newly settled areas in the Victorian Mallee have become infested with Flag Smut. Crops on new land in these areas, farmed with tractors only, and sown with pickled seed, have been found to contain infected plants.

Object and Scope of the Investigations.

In recent years, Flag Smut of wheat has become increasingly important in Victoria, due in a large degree to the widespread use in this State of susceptible varieties, and to the fact

that the presence of this disease in a crop is not readily detected by farmers, so that proper precautions are not taken to protect subsequent wheat crops on an infected area. Under these conditions the injurious effect of the fungus tends to become cumulative, with a result that serious losses in yield due to the disease are not uncommon.

In view of this, it was considered desirable to determine the comparative susceptibility of Victorian wheats, and to obtain accurate information as to the relation to the fungus of environmental and other factors, with the object of defining the conditions influencing the development of the disease. As a result of this work, it was thought that some satisfactory method of control of the disease would be evolved.

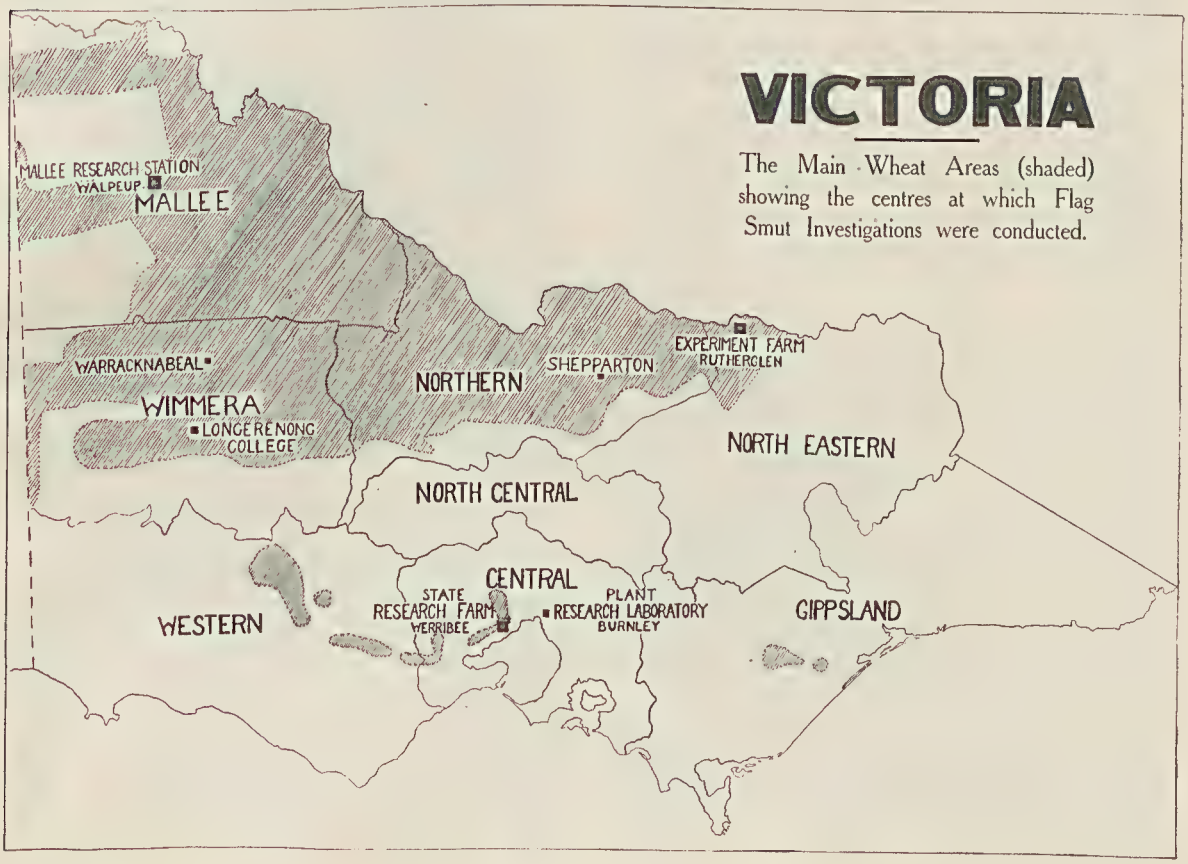
The scope of the investigations included a study of many diverse factors influencing the incidence of Flag Smut and the work is described under the following headings:—

1. *General Technique and Method of Infection Tests.*—A general description of procedure and the results obtained from method of infection tests.

2. *The Effect of Variety on the Disease.*—The reaction to the fungus of the common wheat varieties grown in Victoria and their classification into groups according to their susceptibility to Flag Smut. In addition, several high-yielding crossbreds were tested. A study of the genetics of the disease was also made, with the object of breeding prolific and at the same time highly resistant varieties. The selection of resistant strains was attempted.

3. *The Influence on Infection of Weather Conditions at Seeding Time.*—A study of rainfall and temperature during the susceptible period for infection of wheat with *Urocystis tritici* in relation to the infection which later became manifest.

4. *The Effect of Manurial Treatment on Flag Smut Infection.*—A study of variations in infection induced by different manurial treatments. The effect of locality upon the response, and the nature of the factor causing the variations in resistance was also investigated.



5. *The Effect of Flag Smut on Yield of Wheat.*—A comparison of the losses in yield due to Flag Smut infection in "resistant" and "susceptible" varieties.

6. *Cultural and other Factors in Relation to the Disease.*—Included in this section are investigations on the influence of the following factors on the disease:—

(*a*) Depth of sowing.

(*b*) Cutting back or feeding off.

(*c*) Seed treatment.

Distribution of Experiments.

Preliminary work was conducted at the State Research Farm, Werribee, by the Cereal Geneticist, Mr. A. R. Raw, in the years 1927-30. In 1931, the work was continued at Werribee, and experiments were initiated at the State Experiment Farm, Rutherglen. In 1932, these were extended to include the Mallee Research Station, Walpeup, and Shepparton. During 1933 the investigations were further enlarged, and in addition to the above four centres, experiments were conducted at the Plant Research Laboratory, Burnley (in conjunction with the Plant Pathologist, Mr. D. B. Adam), Longerenong Agricultural College, and Warracknabeal.

These centres were distributed over the principal wheat districts of Victoria, and represented a variation in rainfall and soil type as follows:—

Centre.	Average annual rainfall (pts.)	Soil type.
Rutherglen ..	2,180	Friable red silty loam, usually well drained
Werribee ..	1,931	Poor to fair red volcanic clay loam overlying grey-blue pug clay
Walpeup ..	1,329	Sandy red to grey loam containing a high proportion of limestone
Shepparton ..	1,927	Grey cementy clay loam
Longerenong ..	1,664	Grey clay loam, acting as a self mulching clay, and containing a fairly high lime content.
Warracknabeal	1,505	Mallee fringe, rather heavy red loam

At each of these centres a varietal susceptibility trial was conducted, but the other experiments were sown only at selected places. The main phase of the work at the State Research Farm, Werribee, has been the breeding of prolific, and at the same time resistant, varieties.

1. General Technique and Method of Infection Tests.

The general method of procedure adopted in these trials consisted in sowing infected seed of various varieties of wheat in hand rows, and making counts of the infection which subsequently developed. In certain cases, however, the infected seed was sown in drilled rows, while at Shepparton and Warracknabeal, the practicability of using field infection for the experiments was investigated, when drill rows of uninoculated seed were sown on areas which had previously produced heavily diseased crops.

In conducting Flag Smut resistance tests, some experimenters have used finely minced infected leaves as the inoculum(36, 41), but inoculation with this material does not give completely satisfactory results owing to the difficulty in obtaining a uniform spore load. For the purposes of these experiments, the inoculum consisted almost entirely of spores, and was obtained in the following manner:—Smutted plants were collected from various parts of Victoria at the end of the previous season, and the infected leaves were separated from the rest of the plant. These were then shredded on a coarse sieve, and the spores and fragments of leaves passing through the sieve were collected. The spores were then separated from the fragments of leaves by means of a very fine sieve, and the material so obtained was used as the inoculum.

Preliminary experiments were conducted at Werribee during 1928-30 to determine the best method of infection for field experiments. During 1928, eleven varieties were subjected to eight different modes of infection as follow(74):—

1. Dry spore infection of the seed.

2. Seed infected with dry spores, then germinated in soil from the superphosphate 1 cwt. lime 20 cwt. plot in the Permanent Manurial Field. This plot was heavily infected with Flag Smut in 1927. The seed was germinated in a warm place.

3. Seed germinated on blotting paper, then spore infected.

4. Seed germinated, then spore infected and held in soil until germination was well advanced.

5. Seed mixed with soil from infected plot and sown.

6. Seed germinated in infected soil and sown.

7. Seed germinated on blotting paper, then mixed with soil and sown.

8. Seed germinated, mixed with soil, held in a warm place and sown.

9. Check rows; clean seed.

The plots were sown in single rows of 200 grains. All the soil infections failed, and the infections in all the other cases were low.

The most satisfactory results were obtained from the following treatments:—

(*a*) Seed germinated on blotting paper then spore infected—34.5 per cent.

(*b*) Dry spore infection of the seed—20 per cent.

Of these two methods the latter was the more practicable.

It is interesting to note that in 1929 certain plants were inoculated with a hypodermic needle when eight weeks old, and whereas the disease did not appear in the check rows, 10 per cent. infection developed in the inoculated rows.

The results indicated that the method of dusting the seed with spores of the fungus was most acceptable. This method of infection was later modified to that of spraying the seed with water prior to the application of the spore load. This modified method has proved most satisfactory at Werribee where the seed is sown soon after treatment. A similar method has been developed by Jarrett(30).

In preparing the seed for the tests at the other centres, however, the practice adopted has been to inoculate at one centre sufficient seed to sow all the tests, and forward the required quantity to each place. Under these circumstances the seed was dusted with dry spores without any previous spraying, a method which has proved to be quite satisfactory.

"Method of infection" tests confirming the results obtained at Werribee have been conducted at Burnley and Walpeup, and the effect of varying spore loads also was investigated.

The amount of inoculum applied to the seed determined to a large degree the percentage of smut which developed. Heavy dosages of spore material caused a marked increase in infection as compared with that resulting from a lighter spore load. Care was taken in preparing seed for varietal susceptibility and other trials that the rate of inoculation of the various lots of grain required for any particular experiment was as constant as possible. To ensure this, all lots of seed and inoculum were weighed before being shaken up together.

Noble(46) has stated that "infection is more virulent from diseased straw in the soil than from spores dusted on the seed." Plots were sown at Shepparton and Warracknabeal on areas which had previously produced heavily infected crops, to determine the practicability of using this method of infection in conducting Flag Smut susceptibility trials, and to confirm the results obtained by artificial infection. Field infection, however, has proved unsatisfactory, as the infection obtained is much lower than that resulting from inoculated seed, and in addition the variation between check rows is greater. The following is a comparison of the average infection obtained in the check rows at Warracknabeal where both methods of infection were employed:—

	Seed Inoculation (hand rows).	Field Infection (drill rows).
Infection.—	63.7 per cent.	29.5 per cent.

It was found, however, that the proportion of totally infected plants was greater in the drill rows, which fact supports Noble's experience.

The susceptible variety of Free Gallipoli has been used as a check in the tests at all centres except Werribee, where Indian H was used. A check row was sown every fifth row in the varietal susceptibility trials. Previous to 1933, superphosphate was applied to all rows, but in that year no manure was applied to any of the tests with the exception of the manurial trials.

In general, counting has taken place at the end of the season, when the percentage infection in each row has been obtained. Distinction was made between "whole" and "partial" infection to afford an indication as to the severity of infection in any particular variety or treatment, but plants were recorded as "infected" when either type of infection occurred. Macindoe(37) has suggested a

method for estimating the percentage reduction in yield, but adds: "error may arise due to inaccuracy in estimating the percentage damage in each plant." In certain instances two counts were made during the season, one soon after the appearance of the disease, and the other at the end of the season. All plants showing infection at the first count were removed. In this manner an estimate for primary and secondary infection was obtained.

2. The Effect of Variety on the Disease.

Vavilov has stated that the more limited the field of receptibility of a given fungus the greater the chance that varieties in the same species will exhibit different reactions to it. It is recognized that there is marked variation in the reaction of different varieties to Flag Smut. While many resistant varieties are known, various experiments (35, 41, 50) have indicated that many of the standard wheats grown in Australia are more or less susceptible to the disease. No variety of *Triticum vulgare* immune to the disease is known.

In the past, large areas in Victoria have been sown with susceptible varieties, with a result that the disease has become increasingly serious in this State. Little information, other than observational, was available regarding the reaction of many of the wheats grown in the State, so that varietal susceptibility trials, designed to furnish this data were initiated in 1931.

The ultimate object of these experiments was to obtain an average figure for the susceptibility of any particular variety grown under the conditions existing in various districts in Victoria. The figure so obtained would be applicable to the wheat districts of the State as a whole, and would include any possible effect due to locality. During 1931 experiments were conducted at Rutherglen and Werribee, but as previously stated were extended during 1932 and 1933 to embrace finally six centres distributed over the Victorian wheat belt. Check rows of Indian H. were sown at Werribee, but at all the other centres Free Gallipoli was used. To provide a basis for comparison with the results obtained elsewhere, rows of Free Gallipoli were sown at Werribee. In the majority of cases the hand rows were 1 chain long, and the infected seed was spaced 3 inches apart, giving approximately 250 plants per row.

Fig. 8.—Portion of Varietal Susceptibility Trial, Longerenong 1933.

Fig. 7—General View of Flag Smut Investigations, Longerenong 1933.

During the course of the investigations, it was found that the amount of smut which developed in any particular experiment had an appreciable effect upon the results obtained. Where the percentage infection occurring in the susceptible varieties was small, the ratio between the infections of resistant and susceptible varieties was greater than that recorded from experiments in which a more severe infection occurred.

In Table I. the effect of increase in infection on certain varieties is shown. For the purpose of comparison, the figures are based on an infection of 100 per cent. in Free Gallipoli, but the actual infection occurring in this variety is shown in each case. Tests from several centres have been selected to give a range of infection.

TABLE I.—THE EFFECT OF INCREASE IN INFECTION ON DIFFERENT VARIETIES, SHOWING THE PERCENTAGE INFECTION OBTAINED, BASED ON FREE GALLIPOLI= 100 PER CENT.

Actual Percentage Infection of Free Gallipoli.	14%	30%	38%	54%	82%
Free Gallipoli ..	100	100	100	100	100
Federation ..	86	104	142	118	107
Major	57	..	115	103	101
Ranee 4 H ..	28	46	64	66	91
Ranee × Rajah ..	30	52	64	44	62
Rajah	..	40	42	87	61
Sepoy	24	39	48	51	68
Currawa	..	..	12	23	37
Ghurka	0	4	10	12	27
Nabawa ..	1	4	5	3	10

From these figures, it is obvious that an increase in the risk of infection is more important in the case of a variety which exhibits some degree of resistance to the disease than for susceptible varieties such as Federation. It would appear, therefore, that the tests shown in Table I., in which 14 per cent. and 30 per cent. infection developed in the control rows, do not give a reliable indication as to the comparative susceptibility of the more resistant varieties. The inherent resistance of these varieties is not as great as the apparent resistance exhibited under conditions where the risk of infection is low. In view of this, it was decided to exclude the results of all tests in which less than 35 per cent. infection

TABLE II.—FLAG SMUT INVESTIGATIONS, 1931-33. RESULTS OF VARIETAL SUSCEPTIBILITY TRIALS, SHOWING THE PERCENTAGE INFECTION OBTAINED, BASED ON FREE GALLIPOLI = 100 PER CENT. INFECTION.

Variety.	Infection.	No. of Results in Average.	
	%		
Indian H.	117·5	7	VERY SUSCEPTIBLE.
Genoa	112·2	2	
Gallipoli × Major (L6003, H 3–1)	110·0	1	
Federation	108·8	9	
Bena	100·9	2	
Free Gallipoli ..	100·0		
Turvey	95·3	5	
Canberra	94·8	2	
Wannon × Ghurka (L 5031, B 3–1) ..	94·0	1	
Omrah	91·0	1	
Early Bird	89·3	2	
Mac's White	89·0	7	
Major × Ranee (W 4020, K 12–1)	86·4	7	
Major	86·3	8	
Mogul	84·8	2	
Ranee × Gallipoli 58/1, (W 5806, J 3–2–1) ..	83·5	4	
Gallipoli × Nizam (L 5047, B 5–3) ..	79·0	1	
Sultan	78·5	4	
Waratah	78·2	6	
Spelt	74·8	2	SUSCEPTIBLE.
Early Gluyas ..	73·9	6	
Penny	72·9	6	
Nizam	67·1	8	
Ranee 4 H	64·2	9	
Ridit	62·9	2	
Ranee × Rajah (W 5013, E 4)	61·0	7	
Bobin	60·1	3	
Rajah	58·4	9	
C. × M. × G. (W 7319, F 3–4–1–2)	54·5	3	
Sepoy 324J	51·1	9	

Variety.	Infection.	No. of Results in Average.	
	%		
Yandilla King ..	43·2	6	MODERATELY RESISTANT.
Free Gallipoli × Sepoy (L 5052, B 2) ..	41·2	1	
Webster	39·7	2	
Joffre	38·7	5	
C. × M. × G. (W 5319, F 3–3–4)	36·9	3	
Ford	35·8	4	
Gallipoli × Wannon (L 7001, J 26·3) ..	35·4	1	
Currawa	34·7	8	
Caliph	31·5	2	
Warden	25·5	2	
Dan	23·8	2	RESISTANT.
Telfords	21·1	2	
Viceroy × Fed. × Y.K. (L 4038, B 1–3) ..	20·2	1	
Ghurka	18·1	9	
Cur. × Ind. E. × Tels. (W 7800, D 7–2–2) ..	12·4	4	
Sunset	9·3	2	
Forward	8·0	2	
Red Rock	5·3	4	
Florence	5·2	5	
Gallipoli × Graham (L 5034, E 2A) ..	5·1	1	
Nabawa	3·9	9	
Rajah × Gallipoli (W 7495, H 1–1–7–3–2) ..	3·3	6	
Dindiloa	1·4	5	
Cedar	0·3	3	
Geeralying	0·2	4	

Standard Error for an average of 9 results = 4.7; where a smaller number of results are included in the average figure for any particular variety, the standard error is proportionately larger, increasing to 13.5 for a single result.

occurred in the Free Gallipoli check rows. This left the result of nine separate susceptibility trials, from which the susceptibilities of the different varieties were determined. To provide a common basis for comparison, all results were calculated on the basis of Free Gallipoli=100 per cent. It was found that climatic and soil conditions at the various centres did not affect materially the comparative susceptibilities of varieties.

In all, 55 varieties and cross-breds were tested, but only a limited number was included in all the trials. It is obvious that the reliability of the results is influenced by the number of determinations included in the average. In accordance with the method developed by R. Fisher(18), an analysis of variance was therefore obtained for the varieties sown at all centres. These varieties covered the whole range of susceptibility to the disease, and it was assumed that the variance of the other varieties and cross-breds would be similar. The standard error for any susceptibility figure was therefore calculated in accordance with the number of results included in that figure.

It has been found that the experimental error in this type of investigation is large, so that for the purpose of classifying the varieties according to their reaction to the disease, intervals of 25 per cent. have been chosen. When a greater number of results has been obtained, it will be possible to make finer distinctions.

According to the Government Statist, the percentages of the total area sown to the ten principal varieties of wheat in Victoria for the season 1931-32 were as follow:—

Variety.	Percentage.
Free Gallipoli	39.01
Ranee	16.70
Federation	7.23
Sepoy	6.76
Nabawa	4.49
Major	3.60
Nizam	3.11
Currawa	2.81
Penny	2.16
Rajah	2.01
All other varieties	12.12

Comparing this list with Table II., it will be seen that most of the popular wheats grown in Victoria are susceptible to Flag Smut. On the other hand, the trials to date have revealed a very useful group of varieties and cross-breds which are resistant to Flag Smut. Of these, Ghurka, Rajah x Gallipoli, and Currawa x Indian E. x Telfords are most promising. In Variety Yield Trials, conducted over recent years in various parts of the State (Table III.), Ghurka has consistently outyielded all other varieties tested, and preliminary trials with the two cross-breds mentioned have given very promising results. These trials have been carried out on land practically free from Flag Smut.

TABLE III.—WHEAT VARIETY YIELD TRIALS. RESULTS OF TESTS WITH PRINCIPAL VARIETIES GROWN AT THE CENTRES SHOWN.

Variety.	Flag Smut Reaction.	Walpeup (Mallee) Average 4 years.	Rainbow (Mallee) Average 5 years.	Swan Hill (Mallee) Average 3 years.	Longerenong (Wimmera) Average 4 years.	Rutherglen (North-east) Average 3 years.	Shepparton (Northern) Average 4 years.	Willaura (Western) Average 7 years.
		bushel/acre	bushel/acre.	bushel/acre.	bushel/acre.	bushel/acre.	bushel/acre.	bushel/acre.
Ghurka	R	25·7	23·3	34·2	47·2	26·9	24·9	33·4
Sepoy	S	25·7	20·6	32·9	..	22·1	18·8	30·0
Ranee 4 H	S	25·4	21·3	30·6	..	..	23·3	..
Currawa	MR	24.6	..	29·9	..	..	..	..
Free Gallipoli	VS	24·2	21·2	33·1	46·6	23·8	22·2	32·5
Rajah	S	23·7	..	28·8	..	..	..	..
Joffre	MR	24·3	..	..	..	..	..	..
Nabawa	R	24·1	..	26·6	38·3	..	16·2	..
Nizam	S	..	20·5	..	46·2	..	20·3	30·8
Federation	VS	..	19·6	29·3	44·7	23·8	19·5	30·4
Penny	S	..	..	28·3	..	..	..	..
Major	VS	..	..	..	..	23·0	18·8	30·5
Turvey	VS	..	..	..	..	20·3	..	..

R. Resistant. MR. Moderately Resistant. S. Susceptible. VS. Very Susceptible.

NOTE.—All varieties have not been under test at the same time in each district, as many have been previously shown to be suited to certain districts only.

The investigations have shown that the use of resistant or moderately resistant varieties provides a valuable means for the control of Flag Smut, and their continued use should serve to reduce the losses on affected areas. The discovery that the Ghurka variety is resistant to the disease is particularly valuable, as it has been proved a prolific wheat under general conditions in many districts.

On the other hand, the variety Nabawa, which is very resistant, and therefore useful where Flag Smut is prevalent, has not given satisfactory yields in trials on fallowed land under Victorian conditions.

In preparing Table II., no distinction was made between different degrees of infection. The figure obtained represents the maximum susceptibility of any variety under the conditions of the experiment, but this method does not give a complete conception of the reaction of various varieties to the fungus. However, the method used is considered to be the most satisfactory means by which the susceptibilities of varieties can be compared.

From an analysis of infection (Table IV.), in which distinction is made between "whole" and "partial" infection, several points of interest are apparent. It is found that in general the number of "partial" infections greatly exceeds "whole" infections in resistant varieties, but the reverse is not always the case in susceptible varieties, notable exceptions being Free Gallipoli, Mac's White, Major x Ranee, Penny, Rajah, &c. A comparison between the figures from Longerenong and Walpeup also indicates that the severity of infection in any variety is influenced by the total percentage of smut occurring. Where the percentage infection is low, as at Longerenong, the symptoms manifested are not so severe as those which are produced under conditions where a greater amount of smut appears. This conclusion is supported by the results from rows sown with seed receiving varying amounts of inoculum. Lightly inoculated seed results in a smaller percentage infection as compared with grain receiving a

TABLE IV.—VARIETAL SUSCEPTIBILITY TRIALS. ANALYSIS OF INFECTION.

VARIETY.	LONGERENONG.					WALPEUP.									
						Experiment No. 1.					Experiment No. 2.				
	INFECTION.					INFECTION.					INFECTION.				
	Whole.	Partial.	Apparently Healthy.	No. of Plants.	Infection.	Whole.	Partial.	Apparently Healthy.	No. of Plants.	Infection.	Primary.	Secondary.	Apparently Healthy.	No. of Plants.	Infection.
					%					%					%
Indian H.	94	44	123	261	52·9	123	16	15	154	90·0	106	21	54	181	70·2
Federation	76	94	147	317	53·6	141	32	52	214	75·7	93	14	62	169	63·3
Free Gallipoli	13	122	195	330	40·8	50	97	52	199	74·1	100	16	82	198	58·4
Turvey	49	74	200	323	38·1	63	44	77	184	58·1	41	68	75	184	59·3
Mac's White	4	74	254	332	23·5	76	102	49	227	78·4	79	40	71	190	62·6
Major × Ranee	7	85	261	353	26·1	38	136	51	225	77·3	70	49	70	189	63·0
Major	10	116	163	289	43·6	97	49	38	184	79·4	50	47	93	190	51·1
Ranee × Gallipoli	28	65	307	400	23·3	98	69	87	254	65·8	178	21	97	296	76·5
Sultan	15	60	214	289	26·0	133	51	21	205	89·8	74	30	99	203	51·3
Waratah	80	36	203	319	36·4	73	57	80	210	61·9	104	31	52	187	72·2
Early Gluyas	21	98	194	313	38·0	33	72	86	191	55·0	95	26	147	268	45·3
Penny	2	106	192	298	35·6	36	144	51	231	77·9	85	82	86	253	66·0
Nizam	13	46	245	304	19·4	65	70	97	232	58·2	70	21	99	190	54·5
Ranee 4 H.	9	94	269	372	27·6	16	58	69	143	51·8	47	11	123	181	32·1
Ranee × Rajah	31	62	247	340	27·4	76	74	79	229	65·5	54	44	95	193	50·8
Bobin	6	41	209	256	18·4	24	94	102	220	53·6	50	45	86	181	52·5
Rajah	3	57	260	320	18·8	10	150	55	215	74·4	63	44	165	272	39·3
Sepoy 324 J	0	64	246	310	20·6	19	62	102	183	44·3	27	40	103	170	39·4
Yandilla King	0	18	278	296	6·1	28	99	81	208	61·0	66	76	132	274	51·8
Joffre	0	21	285	306	6·9	17	109	84	210	60·0	14	52	124	190	34·8
Ford	1	49	320	370	15·4	40	39	170	249	31·7	21	2	139	162	14·2
Currawa	0	16	312	328	4·9	14	96	86	196	56·1	9	22	141	172	18·0
Ghurka	0	12	285	297	4·0	7	29	135	171	21·0	5	5	171	181	5·5
Curr. × Ind. E. × Tels.	0	7	320	327	2·1	0	57	165	232	24·6	4	15	141	160	11·9
Red Rock	..	..	..	..	..	1	12	206	219	5·9	1	7	197	205	3·9
Florence	0	3	240	243	1·2	1	12	187	200	6·5	1	8	184	193	4·7
Nabawa	0	7	331	338	2·1	0	6	170	176	3·4	2	1	163	166	1·8
Rajah × Gallipoli	0	5	311	316	1·6	1	3	116	120	3·3	0	2	173	175	1·1
Dindiloa	1	0	220	221	0·5	0	4	227	231	1·7	0	3	206	209	1·1
Cedar	0	0	208	208	0·0	0	3	200	203	1·5	0	0	204	204	0·0
Geeralying	0	0	240	240	0·0	0	0	227	227	0·0	0	1	285	286	0·4

heavier dosage of spore material, but in addition the severity of infection is not so great in the former case.

The conditions under which the plant is grown have an influence upon the severity of infection, e.g., it has been shown(24, 30) that the percentage of infection obtainable is considerably greater under glasshouse conditions than in the field.

As shown in Table IV., counts were made at Walpeup on one experiment for "primary" and "secondary" infection. The first count was made approximately two weeks after the disease first appeared. These counts indicate that there is a marked tendency for the symptoms to appear much later in resistant varieties, in contrast with those more susceptible to the disease. It seems apparent that all primary infection does not necessarily lead to totally infected plants, but there is some degree of relationship between these two types of infection.

The reason for the different reactions of wheat varieties is at present obscure, but it has been suggested by Jarrett that there appears to be some relationship between the rate of growth of a variety and its Flag Smut reaction. Certain quick germinating varieties are more "resistant" than other slower germinating "susceptible" varieties.

The dates of appearance of the plants above ground in certain of the rows at Walpeup were recorded, and it was found as a result that differences in the time required do occur. The "resistant" varieties Geeralying, Dindiloa, Cedar, Nabawa, and Florence germinated very quickly, but in addition a number of susceptible varieties appeared about the same time. The foremost of these were Rajah, Gluyas, Penny, Mac's White, Free Gallipoli, Yandilla King, and Joffre. The actual infection figures obtained from these rows are shown in Table IV., and it is interesting to note that in each case the number of partial infections exceeds that of whole infections. It is suggested that the rapid growth of these varieties during the susceptible period for infection resulted in a smaller number of spores infecting the grain, so that the symptoms manifested are not so severe as would be expected from the susceptibility of the variety.

Under the conditions of this experiment, there did appear to be some degree of correlation between the rate of growth of the plant in the early stages and its reaction to the disease. It will be necessary to investigate closely to what extent these traits are inherent, transmissible characters, rather than changeable phenomena due to external factors.

Production of Resistant Varieties.

The main phase of the Flag Smut investigations at Werribee(52) is the breeding of new prolific forms which will be resistant to the disease. For this purpose, use is being made of such resistant varieties as Nabawa, Cedar, and Dan for mating with the more prolific but susceptible varieties at present under cultivation. The progeny of these matings are being subjected to annual infection tests, and the results to date are promising, a number of these selections having successfully resisted the disease for three years.

Biffen(5) indicated that immunity of wheat to infection by certain pathogenic fungi was a Mendelian character, and Verwoerd(68) has shown that susceptibility to Flag Smut is dominant in wheat varieties.

An effort has been made at Werribee to determine the mode of inheritance of the factor for resistance in the mating between Nabawa (resistant) and Indian H. (susceptible). Results to date indicate that resistance to the disease is recessive, and possibly due to a single factor difference.(74)

Selection as a means of increasing varietal resistance to Flag Smut has been investigated by Tisdale and others(66). They have been able to produce five selections which have proved to be resistant to the disease. Similar work by Verwoerd(68) showed that selection produced a distinct decrease in susceptibility in wheat varieties. Results from selection tests in Victoria to date have proved to be very conflicting. A preliminary experiment was conducted in 1933 on seed obtained from a heavily infected Federation row in the Varietal Susceptibility Trial at Rutherglen, 1932. The seed was divided as follows:—

(*a*) Seed from infected plants.
(*b*) Seed from apparently healthy plants.

This grain was heavily infected with Flag Smut spore material, and sown at five different centres the following year. No conclusions can be drawn from the results, as the differences in infection obtained from the five sowings were not constant. Further selections of heads from apparently healthy plants of leading varieties have been made, and a more comprehensive selection test is contemplated.

3. The Influence of Weather Conditions at Seeding Time.

There is apparently little information regarding the effect of variations in soil temperature and moisture on infection of wheat with Flag Smut. The relation of temperature to the germination of spores of *Urocystis tritici* under laboratory conditions has been studied(24, 44, 68), and it has been concluded that the optimum temperature range for germination is 19°C. to 22°C. Jarrett(31) has stated that germination does not occur at temperatures of more than 5°C. above or below this range. Verwoerd, however, has obtained traces of infection at 28°C.

In determining the influence of temperature on infection, it is necessary to consider its threefold aspect:—

1. The effect upon the germination of the spores and the seed grain. As the minimum temperature for the germination of the wheat grain is 3 to 4°C., it is possible for the grain to germinate while the spores remain stationary, when a healthy plant would result even with heavily infected seed.

2. The duration of the susceptible stage of the host plant may be prolonged by damp, cold weather. Provided, therefore, the temperature is sufficiently high to enable the spores to germinate, this tends to compensate to a certain extent for the less vigorous spore germination at these temperatures.

3. At higher temperatures, the rate of growth of the plant is greatly accelerated, so that the low infection at these temperatures may be due to the plants being able to escape infection, or to the inhibition of the spores, or both.

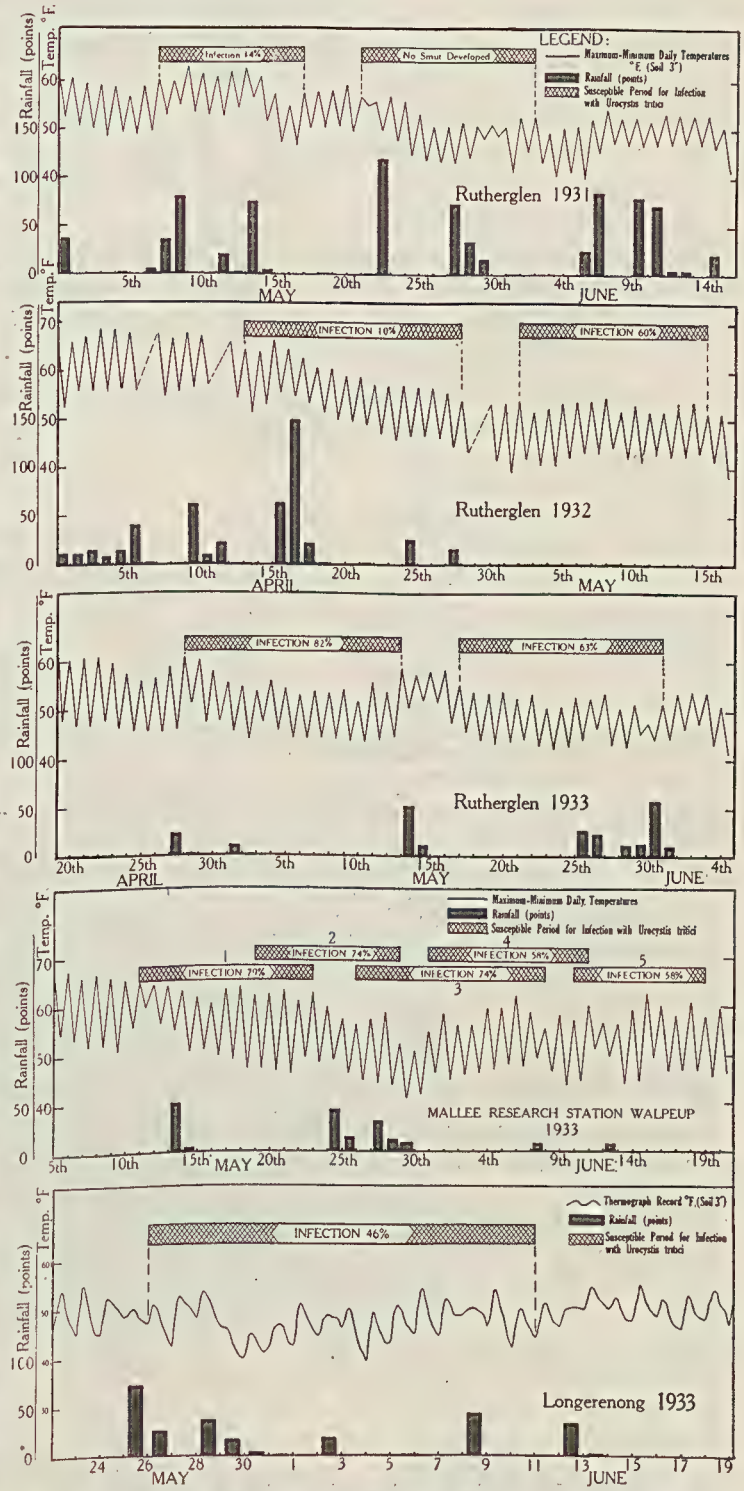


Fig. 9.—Showing the relation between Rainfall and Temperature during the Susceptible period and infection with Urocystis tritici.

In addition to the soil temperature, it was considered probable that the presence of excessive amounts of moisture in the soil would appreciably affect the germination of spores of the fungus, as it has been noted that plants growing on areas on which water tends to collect are often found to be practically free from the disease, even though the remainder of the field be heavily infected. It is recognized that this phenomenon may be due also to the additional moisture favouring the rapid growth of the plant, and hence its apparent resistance to the disease.

It has been generally accepted that early sowing results in a more heavily infected crop than a later sowing of the same variety(38, 65). Actually the weather conditions at sowing time determine to a large extent the amount of smut which occurs.

Woolman(71) has stated that the temperature at and subsequent to sowing is an important factor in the infection of wheat with *Tilletia tritici,* but various workers are not in accord as to what is the optimum temperature.

Since the investigations were initiated at Rutherglen in 1931, maximum and minimum soil temperatures at 3 inches, and rainfall records have been available, and their relation to infection has been studied. In each year two rows 1 chain long were sown with the susceptible variety Federation with a period of approximately two weeks between each sowing, and the infection which later developed in these rows was compared with the rainfall and temperature during the susceptible period for infection with *Urocystis tritici* (Fig. 9). For this purpose, the susceptible period has been taken as from the time of sowing to the date of the first appearance of the plants above ground. In the first two years the rows received a dressing of superphosphate, but in 1933 no manure was used.

It has been shown that the use of superphosphate at Rutherglen reduces the percentage infection, so that the infection figures obtained in 1933 will be high as compared with those that would have been obtained had superphosphate been used.

In 1933 similar observations were made at Walpeup and Longerenong (Fig. 9); the variety used being Free Gallipoli. At Walpeup five different sowings were made over a period of one month, but only one sowing was made at Longerenong, and, in addition, the temperatures at this centre were obtained by means of a thermograph.

The results have shown that the minimum temperature for the germination of spores of *Urocystis tritici* in the soil is less than 14°C. (57.2°F.), which has been previously accepted as the minimum. The temperatures during the second periods at Rutherglen in 1932 and 1933, and at Longerenong in 1933 did not exceed 54°F., and for most of the period were considerably lower, yet a fairly high infection resulted at both centres.

A higher temperature, however, does not necessarily result in an increase in infection, as it is obvious from a study of Fig. 9 that the rainfall during the susceptible period has an appreciable influence upon the disease. If the soil is very wet during the susceptible period, infection is low, even though the temperature is favorable.

The minimum temperature for germination depends upon the moisture present. At Rutherglen in 1931, heavy rain fell during both periods. A small amount of smut occurred in the first period, but the disease did not develop in the second sowing, as the temperatures were lower. Similar temperatures were recorded in 1932, but in the absence of heavy rain, a heavy infection occurred at the lower temperatures.

The effect of differences in the duration of the susceptible stage of the host plant is apparent in the Walpeup results. The soil was bone dry when the first rows were sown, and germination did not commence until after the fall of 50 points of rain on 13th May. The duration of periods 1 and 2 was therefore similar, and the decrease in the infection which developed in period 2 was due to the lower temperatures, and the rain which fell during that period. A longer susceptible period occurred at the third sowing, which probably accounts for the same infection as that obtained in the previous period.

The fourth and fifth sowings were on a lower-lying site, which did not dry out as rapidly as the remainder of the area, resulting in a decrease in infection in these rows, although no large falls of rain occurred. Conditions were more favorable to the disease during period 5, but the shorter susceptible stage only resulted in the same infection as that occurring in the fourth sowing.

From the foregoing it is evident that favorable conditions for germination of spores of *Urocystis tritici* in the soil are the absence of excessive moisture, and the occurrence of temperatures of at least 50°F. The disease is favoured by conditions which increase the duration of the susceptible stage of the host plant.

(To be concluded.)

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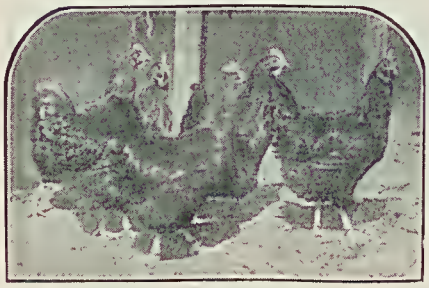

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1928-29	10	13,644	3·41	465·24	512·74
1929-30	10	11,831	3·40	399·45	456·95
1930-31	13	12,763	3·43	431·92	500·01
1931-32	10	10,116	3·69	369·00	417·00*
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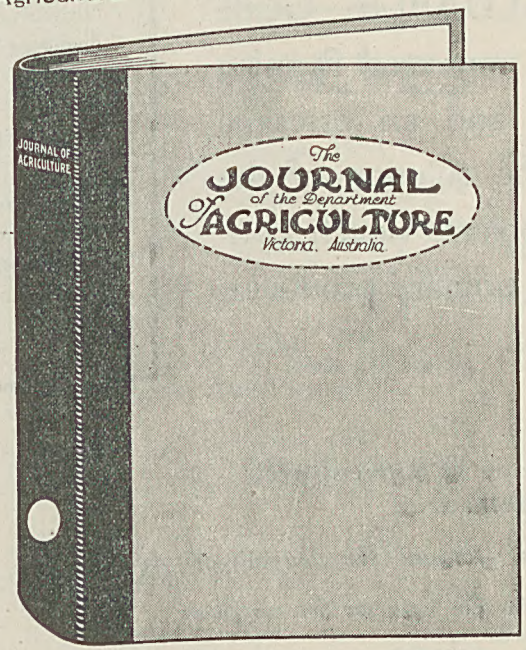

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2 oz. brown sugar.
1 teaspoon spice.
½ cup treacle.
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